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THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, February 18, 1903.

The Bacterial Disposal of Sewage.

BY G. EVERETT HILL.

It will be my endeavor to night to condense within the limits of your patience the salient points which will explain (1) why sewage disposal is of vital interest to a community, (2) the various methods of sewage disposal in use, and (3) the comparative value of these methods.

Whether recognized or not, the mainspring of all human activities, whether physical, mental or spiritual, is the desire to acquire. To get—to have—to enjoy—these are the longings of all; differing widely in manifestation with the individual, but springing from the same principle.

Our lives have grown very complex. Things which our ancestors never saw are necessities to-day; and what we see in Nature's storehouse and want, we do not hesitate to appropriate. We kill the cattle, we cut down the forests, we tear the iron and coal from the bowels of the unwilling

earth; we even appropriate the air and sunshine and use them as slaves to drive our motors and paint our pictures. All this is progress, and a certain measure of progress in acquisition is called civilization.

But acquisition and use must always be followed by consumption and rejection of the products of consumption. Our track of progress is really a trail of desolation strewn with ashes, excrement and rubbish. Even the air is polluted and the sunshine darkened by the smoke and noisome exhalations poured from our factory chimneys. In our instincts of rejection we are still little more than savage. Until *very* recently, few, save perhaps the barbarous Chinaman, dreamed of putting his wastes to any use. Things which we do not want we throw away, and that is the end of our interest in them. Even the poet—who is supposed to be an idealist—instead of putting his rejectamenta into the rubbish barrel or some other suitable place, unblushingly says:

> "Behind us, *in our path*, we
> Cast the broken potsherds."

The sailor alone, who has had an experience denied to the poet, has modified this promiscuous discarding of wastes by insisting that hot ashes—and certain other things—be not thrown to windward.

Seriously, I have not overstated the case. Can we rightly boast of national civilization when less than 4 per cent. of the communities in our country have adopted means for the hygienic disposal of filth; and when the sixth city of the land is riddled—under buildings as well as under yards and streets—with cesspools, whose overflow babbles noisily and noisomely in the street gutters?

But man is learning. So long as the area surrounding his habitation was large, he suffered little recognized inconvenience. But when the farm became a village and the village a town—as the land was divided and subdivided and the houses and population multiplied—he was brought into closer relations with his own offscourings; offense and disease resulted, and it gradually dawned upon his consciousness that either he or it must get off the premises. Consequently, he sought for a new place in which to throw

it, and, grumbling about the cost, built a sewer to the nearest stream. He thought only of transferring the offense to some point beyond the reach of his senses—not of destroying it.

But an epidemic broke out in a town below, which used this stream as a source of water supply; and the resulting suffering and death were found to be entirely chargeable to the community which had "thrown away" its sewage into the stream. The courts were invoked, and future pollution of the stream was forbidden. What could be done with the sewage, now greater in volume than ever and still increasing? The ocean was too remote to be reached; there was no mighty river available which could serve as an outlet.

Then man began to think and to study. He found that sewage was not irredeemable filth. He learned that nature, if encouraged, would turn his foul and poisonous offscourings into clean and harmless mineral forms, and would restore to contaminated water its original purity. He learned, moreover, that this could be done without offense, and close to his own home; that there need be no accumulation of filth, nor any pollution of streams or other infringement of a neighbor's rights; that death-rates can be lowered; that suffering and the expense of sickness can be lessened, and the period of productiveness lengthened.

He *thought* for a while that he had learned more than this. Necessity is a very fecund mother of invention; but, sad to say, prescience is not always the father. The offspring were patents—patents by the score, by the hundred —myriads of patents for "improved" processes of sewage disposal. The sifting of this innumerable company of patents was a long and tedious process. Most of them proved worthless. A few are of great value. The most beautiful children are not always the best, and the processes which brought the bitterest disappointment were those beatific ones which promised financial return from the recovery of valuable constituents of the refuse. Fortunes untold have been sunk in the attempt to make the collection and treatment of sewage profitable. It is true that some pecuniary return may be expected from processes which

are available for use under certain conditions, and such return should be welcomed as a valuable factor in reducing the cost of treatment; but it is not safe to build upon any foundation other than this; *i. e.*, that the disposal of refuse is a vital and costly necessity, a just tax upon those whom it benefits, and that its charges must be estimated as a part of the price of living and paid accordingly.

Self-betterment *per se* cannot be forced upon the individual or the community by any outside influence; but the courts will protect an individual threatened by his neighbor, or a town whose health and comfort are menaced by the act of another town. The common law on the subject is clear and comprehensive; but the growing realization of the danger and the wantonness of stream pollution have led to special and stringent legislation in many of the States. Massachusetts, Ohio, New York, Minnesota and West Virginia were the pioneers in this work. Connecticut and New Jersey seconded them nobly.

In Pennsylvania, I am sorry to say, the bills intended to preserve the lives and the health of the people, by preventing the pollution of water-courses, have been invariably killed by the manufacturing interests, because, forsooth! it is cheaper to poison God's brooks and rivers than to remove or clean their own offscourings. What matters the sickness of the children, the death of breadwinners, if only the brute, commercial industry, is fed!

> "Thus they fling him, hour by hour,
> Limbs of men to give him power,
> Brains of men to give him cunning,
> And, for dainties to devour,
> Souls of children, little worth,
> Hearts of women, cheaply bought.
> He takes them and he breaks them,
> But he gives them scanty thought."

Perhaps you think I speak bitterly. But I know the iniquity; I have seen the harvest. I am now watching, with the gravest apprehension, a case where a State institution of the Commonwealth of Pennsylvania is pouring the sewage from nearly a thousand people into a stream which one can

cross dryshod on stepping stones, while, less than two miles below, lies the water-intake of a town of considerable size. The sentiment of it all is disgusting enough; but one spark of typhoid at the institution above, one moment of carelessness on the part of the nurse in charge and—Heaven help that town!

Before describing the processes which enable us to dispose of our wastes hygienically, let us make sure that we understand what sewage is. Many people conceive it as a dark, turbid, foul-smelling liquid, the very incarnation of concentrated nastiness. As a matter of fact, *fresh* domestic sewage is almost clear, almost odorless and quite inoffensive. One can get a good idea of its appearance—and, what is more, a typical sewage for experimental purposes—by adding a tablespoonful of milk to a pail of water. Floating in this liquid are occasional solid particles of a hundred different kinds, yet strangely alike when their chemical constituents are considered.

Normal sewage contains, in a thousand parts, 998 parts of pure water, one part of mineral matter (largely salt), which is entirely harmless, and one part of dead organic matter. This last named item—insignificant in bulk, for it is but one-thousandth of the whole volume—is the only part that need be considered, for it alone is capable of mischief.

Organic matter is composed, practically, of three mineral elements—carbon, nitrogen and hydrogen—each inoffensive by itself or when combined with oxygen. These elements have been drawn from the soil by vegetation, and the vegetation, in turn, has perhaps been devoured by animal life and appropriated to the building up of its tissues. As these tissues are consumed in vital activities and replaced by fresh structure, they are discarded, and it is at this stage that they are delivered to the sewers.

Sewage also contains considerable vegetable tissue which is rejected (as in the preparation of food) without passing through an animal body. Its constituents and its destiny, however, are similar to those of the animal rejecta. Both are equally capable of causing offence or fostering disease.

In the conservation of matter, as of energy, nothing is ever lost. When a bit of organic structure passes from under the preserving control of the vital force, it must be demolished, and the materials of which it was built must be returned to nature's storehouse for further use. There is thus a constant, circling, interchange between the three physical kingdoms—animal, vegetable and mineral. If it were not so the supply of plant food would soon be exhausted, and life would perish, buried in its own refuse.

There is but one way in which organic matter can be disintegrated—by combustion. The ashes and gases which result from the combustion of animal or vegetable matter are no longer organic, but mineral. Combustion, which is but another name for oxidation, is of three kinds: Igneous, which we call fire; chemical, which is illustrated by the rusting of iron; and bacterial, which is commonly known as decay. The first can attack either mineral or organic matter. It is of little or no use in the treatment of sewage, for the one part in a thousand which we wish to destroy cannot be touched effectively by fire until the 998 parts of accompanying water have been evaporated, The second, chemical oxidation, attaeks mineral matter only, save in a very limited degree. It is of no value in sewage treatment. The third, bacterial oxidation, is the means which nature has provided for the demolition of dead animal and vegetable tissue and the preparation of plant food.

Bacteria, as we all know, are minute living organisms, invisible as individuals, yet so numerous and so active as to balance the energy of all the constructive forces of the world. They are universally present in water, in the air, in the soil, and in our bodies. They have been at work ceaselessly since the first death of the simplest vegetable growth. Since the beginning of history they have disintegrated and returned to the soil a mass of human excreta, which alone would equal 178,000 pounds for each square foot of the earth's surface, to say nothing of the wastes of all other forms of animal life, and the enormous masses of dead vegetation. Manifestly, without their aid, existence would be impossible.

In the popular mind the word "bacteria" still calls up unpleasant pictures of dirt and sickness. The sensational press fosters this feeling, and keeps its readers nervous with tales—and sometimes with astounding pictures—of bacteria in bank notes, on car straps, in carpets and curtains. Patent-medicine vendors advertise their "microbe-killers," which fortunately are not so inimical to the welfare of mankind as their names would indicate. The truth is there are as many kinds of bacteria as there are kinds of men. Some few are known as the stimuli of certain specific diseases, but the vast majority are beneficent. The percentage of hostile forms is lower than the percentage of criminals in the total population; and no greater than the percentage of poisonous plants in the flora of the country. Wholesale germicide, because of the sins of the pathogenic individual bacterium, is as unjustifiable as wholesale homicide, because a criminal happens to be also a man.

There are many varieties of filth-destroying bacteria. Some of them work best without air; some are indifferent as to whether air be supplied or not; and to others air is a vital necessity. Those of the first class are more violent in their action than the others. Properly controlled, they are extremely useful, especially because they are able to break up and liquefy organic solids; but their activities must be directed and curtailed, for they belong to the class from which the criminal, disease-producing bacteria are recruited, and their products, if they are allowed unlimited sway, are foul and disgusting. They are the agents of *putrefaction.*

The air-loving bacteria, on the other hand, work without offence, and complete the mineralization of organic matter by combining its elements with oxygen. A familiar example of their action is the inoffensive decay and disappearance of the dead leaves in a forest. They are the agents of *decomposition.*

The bacterial destruction of filth is not accomplished in a single step. The unraveling of the inter-twisted strands is a complex process. One kind of germ breaks up the carbonaceous matters; another attacks and resolves the albuminoid ammonia; still another *begins* the oxidation of the

free ammonia, but is unable to finish it without the aid of another group. The science of sewage disposal consists in the recognition of the progressive steps of decomposition, and the skilful use of the different groups of decomposing agents in series, so that each, in doing its own part of the work, may prepare the material for effective treatment by the next colony of helpers.

The practical application of these theories is exceedingly simple. The country house-wife who carries a panful of dish-water to her back-door and flirts it over the grass-plot is practising the art of sewage disposal as sanely and soundly as the expert engineer who devises complicated systems of tanks, airlocks, filters, siphons and the like, and then pump millions of gallons through them daily. The active agents and the successive steps towards purification are identical in both instances. The flirting of the dish-water scatters it, so that it strikes the ground, not in a mass, but in a finely divided condition—a film of inappreciable depth. This brings every part of it into intimate contact with air, and spreads it, more or less evenly, over a considerable area of purifying earth. The small solid particles of grease, food-refuse or free soap remain upon the surface, to be slowly oxidized by the bacteria which inhabit it, while the clarified water leaches away into the soil, running the gauntlet of untold myriads of organisms, which ransack every drop in search for food. Before it has gone very far, the water is practically pure; and a little later the retained solids have disappeared, passing off as carbonic acid, water, atmospheric nitrogen or oxidized nitrogen.

These conditions may be maintained indefinitely, if the water be not thrown too often in the same place. After each application, ample time must be allowed for the disappearance of all dampness, in order that air may penetrate the pores of the soil, supplying oxygen needed for chemical combination, and stimulating the air-loving bacteria. If the ground be allowed to become sodden, the air will be excluded from the soil, and putrefactive processes will speedily assert themselves.

This is the sum and substance of broad irrigation, which

has been used, on a large scale, for many years with excellent results by Berlin, Paris and many other large cities. It requires a large area of porous, well-drained land; but, with this given, the cost of preparation is little and operating expenses light. If properly designed and cared for, the installation is permanent. We have in this country no fields commensurate in size or age with many in Europe; but we have excellent examples, on a small scale, of this method of disposal.

Where a sufficient area of suitable land, at a reasonable price, cannot be found, some steps must be taken to concentrate and intensify the purifying process, so that the same results may be obtained more quickly and in less space.

The first step made in this direction was the development of the process known as Intermittent Downward Filtration. This differs from irrigation only in that it employs a filtering medium so exceedingly porous and well drained that air can follow the descending sewage to a considerable depth. The zone of purification is thus extended downward and the capacity of a given area greatly increased. Occasionally beds of natural sand are found admirably suited for intermittent filtration; but any porous material will answer—gravel, broken stone, burnt clay, coke, coal, slag or shells. The purification depends, not upon mechanical straining out of impurities—though the word "filtration" might seem to indicate this, but upon the detention of the sewage, for a sufficient period, within a medium colonized with the purifying organisms and thoroughly aerated from time to time.

One common type of intermittent filter, known as the "contact bed," devised by W. J. Dibdin, late Chemist of the London County Council and Metropolitan Board of Works, consists of a pit (often a simple excavation in earth, but preferably lined with concrete or other masonry) filled with some coarse-grained substance like broken stone, coke, slag clinker, or even cinders—though the last named are hardly suitable because of their tendency to disintegrate. Each "unit" consists of a number of these beds—usually four or five—which are filled in turn, allowed to stand full for a while and then drained.

While the beds are standing full of stagnant sewage air is, of course, excluded, and oxidation is limited by the amount of oxygen *stored* in the bed or derived from the sewage itself. As the liquid subsides, air follows into the interstices of the filter and aerobic bacterial action is stimulated, sweetening the mass and storing a measure of oxygen for use in the next filling. The beds are filled and emptied (usually) but two or three times a day and the oxygen inhaled at each draining is but one-fifth the atmospheric contents of the voids, a trifling quantity as compared with the amount needed for the complete combustion of the impurities delivered to the bed. From the standpoint of bacterial economy the principle of operation is defective, for the different groups of bacteria, which should work separately and in sequence, are here huddled together, tenement-house fashion, regardless of their various needs and their mutual antagonisms. The nitrifying agents, which require abundant oxygen, and a food predigested to the point marked by the formation of nitrites, are periodically drowned by a sewage devoid of oxygen and strong in ammonias. As a result the purifying bacteria never attain the highest efficiency. The results are similar to those which would follow the labors of a farmer who stirred together oats, corn, clover, buckwheat and rye, and sowed the mixture broadcast.

For a while this contact-bed system enjoyed great popularity; but its shortcomings have been recognized, and at a recent meeting of eminent English engineers, the concensus of experience showed that "contact beds had not reached the high standard of purification which was once expected."

Far better is the type of filter drained at the bottom by an outlet never closed, and fed with sewage which comes into contact with all the surfaces of the filtering material without interfering with free aeration of the mass. The sewage evenly distributed at the top is never at rest, but is continually moving through the bed and always in one direction, so that each successive stratum becomes the abode of bacteria of a certain family, which are fed uniformly with food suited to their needs and which pass on, to the next group in the sequence, exactly the pabulum

required for its sustenance. To carry out the simile, the oats, corn, clover, buckwheat and rye are now sown each in its own field, and the results are vastly better.

In 1894, it occurred to the late Colonel Waring that absorption of oxygen from the air was a somewhat slow process and that forced aeration of the filtering medium might hasten materially the work of purification. He accordingly established an experimental plant at Newport. Sewage from the main sewer was pumped into a series of tanks. These were filled, respectively, with coarse broken stone, fine broken stone, pebbles, quartz-gravel and coke; and an air-pipe, descending to the bottom of each, introduced a constant blast from a fan-blower. Three of the tanks were operated intermittently, and two of them continuously. In the latter, the flow trickled down in thin films over the particles of filtering material, while a blast from the blower rose continually through the voids between these particles. The results were unexpectedly good, and the effluent was much purer than the Newport city water supply. It was collected in a square wooden tank, and in this we kept live fish. Since then the system has been introduced in many places. This system combines the maximum of purification with the minimum of land requirement. An area 8 feet square will purify 1,000 gallons of sewage a day. The operation of these filters involves the expense of running a fan-blower; but this is inconsiderable, especially if electric power, which needs little attention, be used.

All of the processes thus far described are based upon the theory that putrefactive action is to be avoided and decomposition alone employed. Indeed, until very recently, this theory was the very spinal column of the science of sewage disposal. A few years ago appeared what seemed to be a reversion to an old type—the septic tank, which has been called a "glorified cesspool." It was remembered that the old cesspools seemed to have a marvelous way of receiving, without any serious accumulation, solids amounting in volume to many times their own cubic capacity. This was well known but not understood. Investigation showed that many of the putrefactive bacteria have the power of lique-

fying organic solids. As these solids have always been more or less difficult to treat, the attempt was made to employ these useful but reprehensible bacteria, and it succeeded. Liquefaction, by anaerobic organisms, is to-day the cheapest and best means of treating the solids of sewage. Moreover, if properly controlled, the process is an admirable preparation for the subsequent oxidation of the dissolved impurities in aerated filters.

In its simplest form the septic tank, or digestion tank, as I prefer to call it, is simply a reservoir, with a capacity equal to the average flow of say twelve hours. The sewage, entering at one end, loses its velocity immediately, and its heavier suspended solids begin to sink, while the lighter rise to the top as scum. This separation of solids and liquid continues until practically all the suspended matter is eliminated. The clarified liquor then escapes gently at the far end of the tank from a plane between the sludge and the scum. This action continues from day to day, the solids accumulating until those which were first deposited, and attacked by the bacteria which colonize the tank, have become liquefied, passing out with the escaping effluent. Thereafter the rate of accumulation is exceedingly slow, for the process of liquefaction offsets the entrance of new solids.

The septic tank, however, must be carefully designed and carefully controlled. The capacity of the tank must be adapted to the volume of flow and means of adjustment provided. Depth must be sufficient to admit of ample sludge-storage and scum-formation, without encroaching upon the section of flow needed for complete subsidence. The current must be effectively checked at the very inlet and a distribution made that will secure the use of the whole cross-section of the tank; otherwise the sewage will pass through rapidly in stream lines while the sides or corners retain indefinitely festering accumulations. The clarified liquid must be withdrawn from the whole width of the tank in such a way that there shall be no considerable increase of velocity at the outlet. Means must be provided for the removal of silt without disturbing the general deposit of

sludge. Light must be excluded; an even temperature must be maintained. The superficial area of walls available for colonization must be the maximum compatible with uninterrupted sectional flow. It is now believed best to construct a tank so that the velocity of flow will constantly diminish, thus securing a classification of the deposited solids. These, and other details with which I shall not burden you, must all be considered in designing a digestion tank.

The effluent from a tank of this kind is not pure by any means. It still contains practically all its original dissolved impurities, though their organic structure has been so shaken and loosened that subsequent purification by any of the processes already described is easy.

Realizing that, in many cases, high concentration of treatment is necessary, and yet the expense of running a blower almost if not quite prohibitive, an attempt was made some years ago to design a high-rate filter through which the sewage would pump its own air. This was successfully accomplished, and the "wave-bed" system is now in satisfactory operation in several towns. Each unit of a wave-filter consists of a long narrow bed, laid on a rather steep slope, preferably walled with masonry and floored with concrete, and filled to a depth of from 1 foot to 18 inches with crushed coke.

This coke is covered with a few inches of broken stone: (1) to hold down the lighter material and prevent washing, (2) to exclude the light, (3) to assist in maintaining an even temperature, (4) to hinder the theft of the coke for fuel, and (5) to present a sightly and uniform surface. The sewage never wets the stone, which always looks as though fresh from the crusher.

The liquid is fed to the head of each wave-bed intermittently, in measured doses, by a siphon, which delivers it faster than the coke can pass it.

By the time the flow of the siphon ceases, a head of water, equal to the depth of the coke, has accumulated at the upper end of the bed; and this passes down through the coke as a wave, flattening somewhat as it goes, but re-

taining its wave form until the bottom of the bed is reached. As the liquid travels through the coke, it drives out ahead of it all the exhausted air and gases of decomposition, and draws in behind it an equal measure of fresh air from the atmosphere. The bed is, in fact, a coke filter 100 feet deep (though laid on its side), no part of which is more than 18 inches away from the free atmosphere; and each succeeding wave pumps fresh air through its entire depth.

The passage of the liquid is so rapid that the purification is not so complete as in the forced aeration system; but it is amply good for all purposes save discharge into a drinking water supply. Our average results run from 84 to 93 per cent. of purification. Analyses made by the Ohio State Board of Health showed that the plant at Kenton accomplished over 94 per cent. of purification. A peculiar and admirable feature of this system is the oxygenation of the effluent to the point of saturation.

The success of either the contact-bed or the various forms of streaming filter depends largely upon the distribution of the sewage. The best method of distribution is undoubtedly hand-control; for the most ingenious mechanism cannot exercise judgment or perform its cycle of operation with the elasticity needed to meet perfectly conditions constantly varying. But hand-control is expensive, and elasticity of operation easily degenerates into irregularity of operation. So that it is usually wiser to trust an unsalaried, uncompromising mechanical device in preference to expensive human fallibility. Many complex arrangements of valves, floats, weights, gears, etc., have been devised; but all of these involve the employment of moving parts, and moving parts mean friction, wear, frequent inspection and attention and eventual renewal. Better, in my judgment, is distribution by means of siphons, airlocks and kindred devices, which consist solely of castings and piping firmly built into solid masonry and without valves or other moving parts. In mechanism of this class, the flow is controlled by air alone, and the air is transferred from one part of the apparatus to another, or released entirely by the rise and fall of the sewage in the several beds. By the automatic airlock device,

sewage can be fed, in sequence, to any number of filters, and any filter once filled can be emptied after any determined interval. Moreover, any filter, or group of filters, may be cut out of the cycle, and the others will continue to operate in rotation. So long as there is sewage to be treated, the actuating power is present, and so long as the atmosphere rests upon the earth, the transmitting agent is ready to do its work. The castings and pipes, if properly painted, will last a generation.

Before closing I wish to say a word or two about the subject of location for sewage disposal works.

Fortunately, topographical conditions usually lead to location in a portion of the community low-lying, and therefore least desirable for residence. But if the works be well-planned, carefully built and *properly operated* there is no *hygienic* reason why they may not be placed in any convenient location.

If a sewage-disposal plant proves offensive, one of two things is certainly true—either the plant is defective or, what is more likely, the system is not cared for properly. The latter trouble is not uncommon, and it is usually due to a resurgence of the barbaric instinct that tries to throw away, without expense, what it does not want. I know of one town that built an excellent modern disposal plant, and then refused to vote $15 a month for its maintenance.

But, no matter what site is chosen, or how excellent the plant and how careful the attention given it, objections are to be expected—either from those who are willing to hinder public improvements by levying more or less open blackmail, or from those sincere, well-meaning folk who are governed by ill-founded fears or misguided sentiment. The fears may be banished by the exhibition of a single good plant; but the sentiment cannot always be dealt with so easily. No man cares to have his neighbors locate his house by saying: "He lives just across the street from the disposal works." But sentiment may be educated. One town not far from Philadelphia turned the landscape gardener loose on its disposal field. With stone walls he trained the brook in the way it should go; he built rustic bridges; he laid

out paths, roads and flower beds; he graded, terraced and sodded. The grass is neatly trimmed, the paths are clean and well kept, and the tract is called frankly The Sewage Park. The entire town is proud of it, and with reason.

The surest index of a community's progress is the treatment accorded to its wastes. Wise is the man who recognizes the evils that threaten him, and takes efficient measures to avert them; but nobler is he who sees in threatening evil the possibility of future good; who knows that in things material as well as spiritual death is followed by resurrection.

Not long since I visited a town to inspect a sewage disposal plant of great interest. I was a stranger without a guide, but I followed the valleys of natural drainage, and these led me unerringly to the works I sought. As I stood on the road at the foot of the town, I saw in the valley below me a long roof which looked as though it might cover the sewage tank. Leaning on a gate near-by stood an old farmer, evidently a Scotchman, whose shrewd but kindly face betokened an interest in my movements. To make sure before descending that I was on the right track, I asked him if he could tell me for what purpose that long, low building was used. He sized me up for a moment before replying, and then said slowly: "It's full of unborn grass and flowers and fruit for God's garden." It was the best definition of sewage I had ever heard.

NOTE.—Mr. Hill exhibited lantern slides illustrating sewage disposal works at Rochester, Brooklyn, Napanoch and Depew, N. Y.; Willow Grove and Rosemont, Pa.; East Cleveland and Kenton, O.; Collingwood, N. J., etc., and described the various methods of construction employed.

A DIVISION OF TESTS ESTABLISHED BY THE SECRETARY OF AGRICULTURE.

The following special order has been issued by Secretary Wilson, of the U. S. Department of Agriculture, viz.:

It is hereby ordered, That there be, and there is hereby, established in the Bureau of Chemistry of the United States Department of Agriculture a Division to be known as the Division of Tests. The work of this Division shall be to test and investigate road materials and all materials of construction relating to agriculture, and to do collaborative work provided by law with other Departments which may require such assistance from the Secretary of Agriculture. This order is to take effect July 1, 1904.

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, November 16, 1904.

The Telegraphone.

By Dr. Z. B. Babbitt.

It affords me great pleasure to come before you this evening to introduce to your attention one of the great scientific discoveries of modern times—the telegraphone.

About four years ago an invention termed the "telegraphone" was announced, whereby it was possible to record and audibly reproduce telephone messages, and to erase such record without loss of record material. The basis of this discovery was surprising, as it proved to physicists that magnetism could be localized.

The discovery and invention was made by a Danish engineer, Valdemar Poulsen, of Copenhagen, Denmark.

To bring to your attention the primitive telegraphone, conceive a piece of steel wire, generally known as "piano wire," stretched between two points; take an ordinary electro-magnet and connect the coil of it in circuit with the secondary of an induction coil, the primary of which is in circuit with a microphone and battery. On speaking into the microphone, induced currents of electricity produce continuous variations in the field strength of the electro-magnet, and if we slide the electro-magnet along the steel wire, the magnetic fluctuations of the electro-magnet affect the steel wire in the form of variable magnetic intensities. There have been impressed on the steel wire undulations of magnetization, a kind of writing that is permanent and which faithfully records the articulations of the voice. If the coils of the electro-magnet are connected with the telephone receiver, and the magnet is made to travel over the steel wire again, the telephone receiver repeats what was spoken into the microphone; or, in other words, acoustic vibrations, analogous to the original vibrations of the microphone, are reproduced in the telephone receiver. A special feature of

the telegraphone in its different forms is the ease with which the record may be erased, it being only necessary to saturate the steel wire with magnetism by drawing it in front of a more powerful magnet so as to equalize the magnetic level differences created by a record, the wire then becoming as susceptible to further records as it was before.

One of the first machines (the one which gained for Poulsen the medal at the Paris exposition in 1900, for original electrical research) consisted of a framework carrying a brass cylinder and a magnet-carrying device, so designed that the pole-piece of the magnet traversed the steel wire, about 1 millimeter in diameter, which is wound upon the cylinder in the form of a helix. The arrangement being, that the pole-pieces of the magnet shall rest upon the steel wire while the machine is recording, reproducing, or erasing. This machine had a length of time record of fifty seconds, being at that stage purely scientific. The space occupied by the machine was about 15 inches by 7 inches base and 7 inches high. It can readily be seen that as a commercial article it had no value, and that one of the first problems was to reduce the compass of the machine, this being done in various ways.

About a year and a half ago Mr. Poulson began using an arrangement analogous with mechanical phonographs. A polished cylinder of magnetical hard material and of similar dimensions as the well-known wax cylinders in use. The speed was about $\frac{1}{2}$ a meter per second, and the pitch of the screw about $\frac{3}{10}$ of a millimeter, or about $\frac{1}{80}$ of an inch. On account of these dimensions the pole of the magnet must be pointed. These cylinders gave good reproductions, adjacent lines showing no interference.

Mr. Poulsen, in a later form of apparatus, replaced these cylinders by steel disks about $4\frac{1}{2}$ inches in diameter and about $\frac{1}{20}$th of an inch in thickness. The portability of these disks, the susceptibility of receiving records on both sides, the instantaneous erasure of records at will and the absolute secrecy of the subject matter of the record, lead one to believe it will, in the future, be a means of inter-communication superior to letter-writing. This machine weighs

about 15 pounds, and is of about the same dimensions as the phonograph.

The most important step, however, in reducing the compass of the machine lay in the use of a smaller wire. The machine shown you to-night represents the latest type of telegraphone. The wire on it being only $\frac{1}{100}$th of an inch in diameter, has solved the question of length of record that can be made. This small machine has a time capacity of 30 minutes, and, as the length of record depends upon the length of wire used, it is simply a question of increasing the dimensions of these spools to give a time capacity of two or three hours.

This machine has the ability of performing five different functions, which, briefly stated, are as follows: (1) It receives dictations; (2) it reproduces to the dictator; (3) it reproduces to one at a distant point, the machine being under control at that point; (4) it records conversations between two persons over the commercial telephone lines without in any way interfering with the operation of those lines; (5) it records automatically, in the absence of the subscriber from the office, messages coming over the line during such absence, the machine being under the absolute automatic control from the ordinary performing function of the telephone line, the ringing of the bell starting the machine, the machine sending a signal over the line to the party talking, notifying him that the machine is running, the machine running a fixed length of time, sending another signal, then automatically stopping.

This instrument is of such a size as to permit it to be placed conveniently on a writing desk or a small table.

The wire runs between two pairs of magnets, placed horizontally on each side of it, at a speed of about 10 feet a second. The driving apparatus is a small electric motor, 110 volts, D. C., contained in the box. The record is effected by the action of the left-hand pair of magnets, facing you, the other pair of magnets being used for erasing.

The switch-box, as you see, is fitted with three press buttons, by which the recording wire can be run forward or backward or stopped.

As the erasing magnet is in operation when the wire is run forward, any portion bearing a record which is no longer required, can be utilized for a fresh record, the wire being cleaned by the erasing magnets immediately before entering the field of the recording magnets. It will be seen from this that the mere fact of making a record wipes out or erases any previous record on that part of the wire; this enables one, when dictating, to correct an error.

This other switch-box, as you see, is connected by a considerable length of cable to the machine, and is for the use of the typewriter in taking off dictation. This head piece enables the typewriter to hear the dictation. When used for dictation or recording direct the machine is spoken to through this transmitter. The machine is set in motion by the depression of the forward button in the switch-box, and the speaker having finished, the stop button is pressed.

The typewriter having taken as many words as he can memorize, depresses the stop-button, typewrites and repeats the process until the end. The motor does not stop dead, but reverses the running of the record for a few seconds, thereby enabling him to hear the last portion of the matter already heard. The other button enables him to run back as far as he wishes.

This application of the telegraphone dispenses with the services of a stenographer, and also leaves the principal free to dictate his letters at such intervals as may be most convenient to himself. It also provides absolute privacy to him, a fact not to be ignored, for a communication may be of such a nature that the presence of another person is sufficient to divert the mind.

Another type of machine is used for the telephone distribution of news, market quotations, music, etc. The reproduction is audible to any number of persons, whether present in one place or scattered over a wide area.

We think you will be interested to know that the King and Queen of England, during their recent stay at Copenhagen, visited the office of the Danish Telegraphone Company, where they remained for nearly an hour, and showed the keenest interest in this epoch-making invention of

Valdemar Poulsen. Speaking into the instrument, His Majesty said: "I am very much interested in having seen this wonderful machine, and feel sure it will be of great benefit and value."

Kelvin, Marconi, Silvanus P. Thompson, Alexander Graham Bell, Tesla, M. J. Garvey, A. W. Heaviside, Dane Sinclair and many others have given autograph letters of interest and approval of the invention.

What influence is the telegraphone destined to exert in human life?

The reproductions are true to the human voice either conversational or in song, and the day will come when every family will have records made at frequent intervals—from the child's first efforts at speech through an entire life; and families will prize these records as they do photographs; national bureaus will be established for the preservation of records of speeches of our public men and women; correspondence will be carried on by the use of the disk machine in preference to the present methods.

Many business transactions are carried on daily over the telephone, and the day is at hand when telegraphone records will be made of each and every transaction and filed away for reference. The telegraphone is destined to take the place largely of the present stenographer, and no business or professional man will think of writing his business letters, lectures or sermons.

The loud-speaking device, which is nearly ready for the market, reproduces sufficiently loud to fill a lecture hall, and makes it not only possible, but probable, that the telegraphone will play an important part in the entertainment field.*

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* At the close of the meeting a demonstration was made of the operation of the telegraphone.

THE BROWN WIRE-WOUND GUN TESTS.

The tests of the 6-inch Brown segmental wire-wound gun, 50 calibers long, now going forward at the Government proving grounds at Sandy Hook, are said to have been so successful that it is claimed a new world's record for heavy ordnance is assured. The Board of Ordnance and Fortification some months ago made an allotment of $41,000 to build and test one of these guns with 250 rounds of ammunition. The New York *World* states that six rounds have already been fired. The initial round, with 32 pounds of powder, produced an initial velocity of 1,913 feet per second. The weight of the charge was increased thereafter, until with 64 pounds of powder a velocity of 3,178 feet per second was obtained, with a pressure of 33,450 pounds per square inch. The tests, which are made with smokeless powder, will be continued until 250 rounds have been fired. The velocity attained with the charge in the test of December 7th already establishes a new world's record for this type of gun. It is expected that a velocity of 3,500 feet per second will be attained with a pressure of from 43,000 to 45,000 pounds per square inch. It is stated that the gun will safely withstand the above pressure of 45,000 pounds per square inch, and that consequently the velocity of 3,500 feet per second, which will establish a new world's record, is assured.

RAPID ADVANCES IN RUBBER.

Manufacturers of articles in which rubber is used are confronted by radically increased costs on the raw rubber. Notwithstanding the fact that the production of rubber is increasing rapidly each year, the increase in consumption is in a ratio so much larger that prices are mounting skyward, and there is no little danger of an actual shortage. The highest price for pure Para rubber in 1880 was 50 cents per pound. The average price from 1885 to 1892 was 76 cents. The price in March, 1902, was $1.02. The price November 1, 1904, was $1.13, and prices quoted the past week range from $1.30 to $1.32½. These prices are all f.o.b. New York in car lots. At no period since rubber has been a large commerciol commodity have price-increases been as startling as during the last few months. During the month of November a total of 14 cents was added to the wholesale prices.

There are a number of natural reasons for this increase in the price of rubber apart from whatever manipulation may be present in the market. The small item of rubber heels to shoes has consumed quite a tonnage. Automobile tires call for the purest rubber in a larger proportion compared with adulterants and fabric than in most other arts. The widespread use of rubber tires for carriages and other vehicles consumes to-day a greater tonnage than the total importation of rubber twenty years ago. It is estimated that last winter no less than 60,000,000 pairs of rubber boots and shoes were manufactured and sold. The rubber industry is daily assuming larger proportions and greater importance, and rubber is finding its way into a countless number of manufactured products in which it was not used some years ago. The rise in the price of raw rubber is therefore quite in line with the progress of the industry.—*Iron Age.*

The Effect of Preservatives on Health and Digestion.*

By H. W. Wiley, M.D.,
Chief of the Bureau of Chemistry, U. S. Department of Agriculture, Professor of Agricultural and Hygienic Chemistry, Franklin Institute.

The question of the use of preservatives in food products is one of foremost importance. Not only is it a question which concerns the public health, but also one which concerns the character of commerce.

That food must be preserved is self-evident. It would not be possible nor desirable that every food should be consumed the moment it is ready for consumption. The various industries in which humanity is engaged, the development of means of transportation which bring all climates and all countries together, the use of food in long voyages of discovery, in mining camps, in the army and navy, as well as its general use in many other instances, make it necessary that it should be preserved.

Many foods, and those of the most important character, are self-preserved—for example, the cereals, nuts, ripe beans and peas. Other forms of food are preserved naturally for a greater or less length of time, such as fruit, berries, eggs and meats. Still other forms of food begin to decay soon after they are perfected; fish and oysters are types of this character of food.

Modern civilization demands that food shall be manufactured and preserved and made more or less ready for use. In these processes, from the earliest times well-known methods of preservation have been practised. The removal of water from a food product is a method of preservation which has been practised from the earliest times. The use of certain condimental substances, such as salt, sugar, vinegar and wood smoke, has also been practised from the earliest periods of history for preservative as well as condimental purposes. During the last hundred years the sterilization of food by heating and the exclusion of the germs there-

* A lecture delivered before the Franklin Institute in Association Hall, Philadelphia, Friday, November 4, 1904.

from have been practised on a large scale and is still one of the safest and most approved methods of preservation.

Since the development of the method of making artificial cold, cold storage has played a very prominent part in preserving food products. It may be said that no reasonable objection can be made to any of the above processes provided they are conducted in a rational way and for a reasonable length of time. For the past fifty years, however, there has grown up a system of food preservation based on the use of so-called antiseptics, that is, chemical products which of necessity must be colorless and without taste or odor and which have the power of paralyzing or destroying the fermenting germs which cause food to decay. It is this class of preservatives to which attention is directed at the present time. The more common of these are well known, such as boric acid, borax, salicylic acid, benzoic acid, sulphurous acid, formaldehyde, etc. Concerning the use of these bodies the greatest difference of opinion prevails. Many manufacturers and a number of physiologists and chemists claim that the use of these bodies is in no way detrimental and that their use should not be restricted. There is another large class of experts who claim that the addition of such antiseptics to food is reprehensible and that their use should be restricted or even prohibited.

It was for the purpose of determining these points of difference between experts that the experimental work of the Department of Agriculture on food preservatives was undertaken. The results of one series of experiments of this kind have been collated and are almost ready for publication.

In these experiments borax and boric acid were added to food, beginning with small and gradually increasing to large doses per day. The small doses were ½ gram (7½ grains) and the large doses were from 3 to 4 grams (45 to 60 grains) per day. These experiments were carried on during a period of about nine months and the results which were manifested are as follows:

Boric acid and borax in gradually increased doses, with a maximum of from 3 to 5 grams per day, cause a disturbance of digestion and health manifested in loss of appetite,

a loss of weight, a feeling of uneasiness and sometimes of illness in the stomach, a fulness in the head which often developed into a dull and persistent headache, a general disturbance of the metabolic functions of digestion and many other disturbances which were of a markedly unfavorable character.

When borax and boric acid are administered in small doses, namely, ½ gram (7½ grains) per day over a long period of time, similar symptoms in a less acute form are developed in the majority of cases. In one instance, where small quantities of borax were given for fifty days, there was a gradual but not pronounced loss of weight, a gradual and, in some cases, pronounced failure of appetite, a somewhat well-developed feeling of uneasiness in the stomach and a dull but persistent headache, all of which symptoms disappeared within a period of ten or fifteen days after the administration of the borax was discontinued.

In the consideration of the action of preservatives of a mineral nature, such as borax and boric acid, it must be remembered that the animal, as well as the plant, possesses a certain mineral hunger. In other words, mineral substances play a double role in animal and plant nutrition. First, they may serve as real food, necessary to the formation and nutrition of the tissues. In the second place, they are necessary to the functional activity of the various organs of the body, irrespective of any part they may take in direct nutrition.

The necessity of saline solutions in the blood is known to every physician and physiologist. If the blood were deprived of all of its saline constituents, the circulation would be impeded, restricted or stopped, and death would result. In cases of collapse in disease saline injections in the blood are often used as a restorative measure. These salts in solution stimulate the heart's action, and undoubtedly are active in the osmotic operations of the cells. This is one of the facts which show the intimate relation existing between physical chemistry and physiology.

Common salt is the most frequent and most abundant of the saline constituents of the blood, but the alkalinity of the blood is not due, of course, to common salt, which is a

neutral substance. The existence of alkaline carbonates or other alkaline salts is necessary to the vital functions. While it is true that the digestion in the stomach takes place in an acid solution, it is likewise true that any excessive acid must be neutralized and enough of alkali added in the small intestine, in order that the further digestion of the food may properly take place. That saline bodies other than common salt or the alkaline carbonates may be useful, however, in the performance of the vital functions cannot be denied, though it might be difficult to demonstrate their absolute necessity. Hence the introduction of saline bodies, which may or may not be of an antiseptic character, may, within certain limits, have a favorable influence upon health and digestion. At the same time it should not be forgotten that all excess of such bodies imposes upon the excretory organs an additional burden, which, while it might not impair their efficiency even for a number of years, might finally induce a condition of exhaustion which would be followed by serious consequences. Especially is this remark true of the kidneys, which appear to be a general clearing-house for all the surplus of saline matters ingested in the foods.

Are Minimal Quantities of Preservatives Permissible?—It is admitted by all who have examined the subject in a critical way, even by the users of preservatives, that in certain maximum quantities the limit of toleration is reached in each individual and positive injury is done. But it is also well recognized that many, if not all, of the usual foods when used in large excess produce injurious results. The many cases of disease produced by overeating, or by eating improperly prepared or poorly cooked foods, or by eating at unusual times, are illustrations of this fact. Upon this basis and upon the further statement that, when used in extremely small quantities, the preservatives in question cannot be regarded as harmful, is founded the principal argument in favor of the use of the preservatives, aside from the fact that the foods themselves are kept in a better and more wholesome state.

It is only proper to give to this argument full consideration and not to brush it aside as illogical and irrelevant. It is evident that any attempt to determine experimentally the

effect of extremely minute quantities of any preservative, even when used continuously, would not be likely to lead to any definite result. In the foregoing data we have illustrations of the fact that even large quantities of the preservative employed—larger by far than would probably ever be found in any food product—do not always act in such a way as to permit of definite interpretation. The claim, therefore, that the use of such preservatives is justified when the amount is extremely small, and when even these small amounts are used only at intervals, and not continuously, is worthy of careful consideration.

An illustration which is pertinent may be taken from the particular preservatives with which the foregoing experiments have been made, namely, boric acid and borax. One of the food products to which these preservatives are very commonly added is butter. This statement should not be taken to imply that in butter prepared for domestic use in this country borax is found to any considerable extent. When butter, however, is to be transported over long distances, and necessarily kept a long while, the addition of borax is very frequently practised.

The dietetic data which have been accumulated in the course of this experiment show that the quantity of butter consumed daily varies from 30 to 70 grains. Suppose, as a maximum, we say that the quantity of butter consumed in any one case daily is 100 grams, and that it contains 1 gram of boric acid, or an amount of borax equivalent thereto. The maximum quantity of boric acid used in a day in this case would be 1 gram. In point of fact, however, it would rarely, if ever, reach this amount, but even in those cases where butter is eaten freely probably half a gram would be about the maximum quantity consumed. Further than this, 1 per cent. of boric acid, or its equivalent in borax, in butter is a very large quantity. Probably, as a rule, not more than one half of 1 per cent. is employed. In this case the quantity of boric acid likely to be consumed by any one individual in a day would be reduced to one-quarter gram.

In the case of meats preserved by borax, although larger quantities are eaten than of butter, it is not likely that any larger quantities of borax would be consumed. Thus it

appears that those who habitually eat butter and meat preserved with borax might be consuming half a gram or a little more of boric acid per day. But preserved meats are not regularly eaten, and hence the quantity mentioned is likely to be overestimated. It would be unwise to affirm in a case of this kind, in the light of the data obtained by the experiments, that such a minimum consumption of borax, and especially when not a continuous one, would prove deleterious within any reasonable time of observation. The question then arises, Does the absence of such proof or the impracticability of obtaining it serve as a justifiable excuse for the use of this preservative?

This question ought not to be decided alone, because the principle of the decision must stand, not only for boric acid and borax, but for every preservative used in foods. In other words, whatever principle is established for judgment as to the use of boric acid in small portions must also be applied to the use of every other preservative used in foods. The principle must also be still further extended, so that whatever may be established as regards butter or meat must be admitted in respect of every other substance used in food. Hence, before admitting the full force of the argument based on minimal quantities, the full significance of such an admission must be considered and the practically unlimited extent of its application acknowledged.

This leads to the discussion of the fact that in the majority of cases the labor of freeing the system from added preservatives falls principally upon the kidneys. In the method of life in vogue in this country the kidneys are already hard-worked organs. Americans probably eat more freely than the citizens of almost any other country, with the possible exception of England. Large quantities of nitrogenous foods are consumed. In the breaking down of the nitrogenous tissues the kidneys are the chief organs for the excretion of the debris. The addition of any further burden, therefore, no matter how minute, is to be deplored. If, however, the principle be admitted that injurious substances may be used in such small quantities as to be practically harmless, then we find the way open for loading upon the kidneys many different functions in addition to

those which they now discharge. If they may be justly called upon to eliminate the small quantities of boric acid added in food, they can not logically be freed from the necessity of eliminating also minute quantities of salicylic acid, saccharin, sulphurous acids and sulphites, together with the whole list of the remaining preservatives, which are eliminated principally through the kidneys. It would be useless to contend that the occasional consumption of small quantities of boric acid in a sausage, in butter, or in preserved meat would produce even upon delicate stomachs any continuing deleterious effect which could be detected by any of the means at our disposal, but naturally it seems that this admission does not in any way justify the indiscriminate use of this preservative in food products, implying, as it would, the equal right of all other preservatives of a like character to exist in food products without restriction.

It appears, therefore, that there is no convincing force in the argument for the use of small quantities unless it can be established that there is only a single preservative used in foods, that this preservative is used in only a few foods, that it will be consumed in extremely minute quantities, and that the foods in which it is found are consumed at irregular intervals and in small quantities. On the other hand, the logical conclusion which seems to follow from the data at our disposal is that boric acid and equivalent amounts of borax in certain quantities should be restricted to those cases where the necessity therefor is clearly manifest, and where it is demonstrable that other methods of food preservation are not applicable and that without the use of such a preservative the deleterious effects produced by the foods themselves, by reason of decomposition, would be far greater than could possibly come from the use of the preservative in minimum quantities. In these cases it would also follow, apparently, as a matter of public information and especially for the protection of the young, the sick and the debilitated, that each article of food should be plainly labeled and branded in regard to the character and quantity of the preservative employed.

Borax and boric acid are regarded by most experts as the

least harmful of the antiseptics usually employed. Whether this is a true view of the matter or not remains to be determined by subsequent experiments. It is evident, however, from the results of experimental work that the miscellaneous and premeditated use of these antiseptics in food is reprehensible. There may be occasions when the use of borax is advisable, as, for instance, where butter must be shipped many thousands of miles before it is used or where meats are to be sent across the ocean, and perhaps in various other instances which render imperative the use of a preserving agent. It follows, therefore, that foods should only be preserved with a view to special use. When they are intended for consumption within a short time and for the ordinary continuance of life, it does not seem necessary that any antiseptic should be used, as the food can be perfectly preserved by unobjectionable methods in some of the ways indicated above. Where foods are prepared for various purposes, such as long journeys, excursions, voyages of discovery, etc., as indicated above, it appears that borax could be employed properly if its use is demanded by those who order the food, and if the food products are plainly labeled as having been preserved by this substance. It is, moreover, evident that eating small quantities of borax in food, occasionally, would not prove of any lasting injury to the ordinary citizen in good health, but the weak and feeble must be protected, and it is entirely within the grounds of reason that even a very small quantity of an antiseptic of this kind would prove very harmful to a disordered stomach.

The safest rule, therefore, to follow is to exclude these bodies from food except when their use is imperative, and then the quantity of the antiseptic employed should be plainly stated in such a way that the consumer may know what he is eating.

Similar experiments to the above have been conducted with salicylic, benzoic and sulphurous acids, but the results of the experimental work have not yet been compiled nor have the conclusions been drawn. This work is to be continued during the coming year, when it is our purpose to determine the effects of formaldehyde and coloring matter, when added to food, upon health and digestion.

The Value of the Flame of Combustibles.

By P. Mahler,
Civil Engineer of Mines.

Translated from the "Revue Universelle des Mines," Volume V, 4th Series, page 1, 48th year, 1904,

By B. F. Isherwood,
Chief Engineer, U. S. Navy.

I. Value of the Flame of Combustibles.

The calorific power and the chemical composition are, in general, sufficient elements of comparison between natural combustibles. These data permit, notably, the calculation of the value of flames, and the question may be asked whether this calculation has any practical utility.

The value of the flame of a combustible is the same thing as its temperature of combustion under constant pressure. It is measured by the thermometric degrees through which the gaseous products of the combustion are raised, supposing them to be heated by all the heat due to the combustion and solely by that heat. It must also be admitted that the combustion is complete and that it is realized by the aid of air under the atmospheric pressure, always nearly constant, as it takes place on grates.

The preceding definition is in accord as much as possible with industrial conditions; but, in fact, the temperature of combustion is a theoretical number defining with precision a limit that practical industry cannot exceed with any given combustible and for the given bodies to be heated; and it seems interesting to compare different coals from this point of view.

The calorimetrical bomb and the elementary analysis having supplied* me with the necesary data for the calculation of temperatures of combustion, I have determined the value of the flames of a complete series of combustibles.

* "Etude sur les Combustibles," by P. Mahler, 1903, published by Beranger.

II. Determination of the Temperature of Combustion.

The determination of the temperature of combustion is done without difficulty, and the method I have followed is an old one. Nevertheless, I will cite the principal points because they can be of service to engineers in many cases, as in the examination of the functioning of furnaces,* and of the economic results of gas-motors calculated from the temperature of detonation of an explosive, etc.

Be q the calorific power of unit of weight of a combustible under constant pressure. Be C_m the mean specific heat† between O and T, absolute temperature of any one of the gases whatever composing the gases of combustion; let it be taken in relation to the weight of the gas which occupies a volume equal to 22·3 liters. Be N the number of molecules (22·3 liters) of this gas resulting from the combustion. As the energy of a gaseous mass depends wholly on its temperature, and as the coal in question is burned at a temperature very near 0° C. or T_0, the heating due to the combustion between T_0 and T_1 is, according to our hypothesis, united closely to the calorific power by the expression

$$q = \Sigma N(C_m T_1 - C_m T_0),$$

Σ signifying that the gases of combustion are a mixture of several gases for which N and C_m have special values.

The analysis of the combustible gives N, and if C_m were constant, we could easily deduce from the above equation T_1, since the temperature sought for $\theta = T_1 - 273°$ in Centigrade degrees.

But the problem is more complex. Messieurs Mallard and Le Chatelier have demonstrated that the specific heat of the gases of combustion increase with their temperature, this phenomenon becoming very sensible at high tempera-

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* "Le Chauffage Industriel," by Mr. E. Damour.

† dq being the elementary heating of 1 kilogramme, the true specific heat at the temperature t is

$$\frac{dq}{dt} = c$$

by definition.

Between the true heat and the mean heat from o to t, we have, in general, the relation:

$$\int_o^t c\,dt = Cmt, \quad c = \frac{dCmt}{dt}.$$

tures. According to these physicists, it should be represented by a function

$$C_m = a + \beta T.$$

The calculation of T_1 and, consequently, of θ, depends then on an equation of the second degree:

$$q = \Sigma N [(a + \beta T_1)\, T_1 - (a + \beta T_0)\, T_0]$$

$$q = \Sigma N [a\,(T_1 - T_0) + \beta\,(T_1^2 - T_0^2)] \qquad (1)$$

Messieurs Mallard and Le Chatelier have deduced from their experiments the values of a and of β relative to the different gases.*

I ought to say that in these later days, certain very exclusive partisans of the law of Clausius regarding specific heats, have contested the law of increase shown by Messieurs Berthelot and Vieille and by Messieurs Mallard and Le Chatelier. The law of increase, nevertheless, does not for this reason appear any less conformable to the truth. And if we reflect on the considerable difference existing between the temperatures of combustion calculated according to this law and the highest temperatures obtained in the best industrial furnaces (Martin-Siemens' furnace, 1,600°), we may even suppose—for the effect of the dissociation is feeble—that the increases resulting from the known experiments, are inferior to the truth.

Under any circumstances, the exactness of the experiments of Messieurs Mallard and Le Chatelier certainly surpass the precision I need for the comparative investigation that is the subject of this note.

Which being premised, we will now return to the calculation of the temperature of combustion of coals and of other natural conbustibles.

The gases of combustion comprise in general only perfect gases such as azote, and incidentally the oxide of carbon,

* Researches, experimental and theoretical, on the combustion of explosive gaseous mixtures; third memoir on the temperatures of combustion and the specific heats of gases at high temperatures, by E. Mallard and H. Le Chatelier ("Annales des Mines," 1885).

Report on the study of the questions relative to the use of explosives in presence of grisou (fire damp); temperature of detonation; by E. Mallard ("Annales des Mines," 1888).

and the condensed gases steam and carbonic acid. Relatively to the perfect gases, the remark must be made that their specific heats are nearly equal at all temperatures between the ordinary atmospheric temperatures and the temperature 3,000.°

According to the above physicists, the following are the coefficients for the above gases.*

Perfect gases	$\alpha = 6{\cdot}5 \times 1{,}000^{-1}$ $\beta = 0{\cdot}6 \times 1{,}000^{-2}$
Superheated steam	$\alpha = 6{\cdot}5 \times 1{,}000^{-1}$ $\beta = 2{\cdot}9 \times 1{,}000^{-2}$
Carbonic acid	$\alpha = 6{\cdot}5 \times 1{,}000^{-1}$ $\beta = 3{\cdot}7 \times 1{,}000^{-2}$

From these result the following expressions of the heating of a molecule of the above gases from T_0 to T_1 in large calories.†

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* "Cours de Chimie Industrielle," by H. Le Chatelier.

† There may be needed the expression of the heating of a constant volume; for example, for the calculation of the temperatures of detonation, and also for the study of gas-motors.

In this case, the coefficients of $[T_1^2 - T_0^2]$ are the same as above, and the coefficient of $[T_1 - T_0]$ is solely

$$4{\cdot}5\,\frac{T_1 - T_0}{100}$$

There may be also need of the heating of a molecule of methane, as follows:

$$4{\cdot}5\,\frac{T_1 - T_0}{1000} + 6\,\frac{T_1^2 - T_0^2}{1000}$$

at constant volume.

The difference between the heating at constant volume results from the difference between the two specific heats $[Cp, Cv]$ a difference due to the quantity of heat absorbed by the work of dilatation accompanying the increase of temperature.

We know, in fact, that the two heats of the heating are connected by the expression:

$$q = Q + A\int_{v_0}^{v_1} p_0\,dv, \text{ or } q - Q = A\int_{v_0}^{v_1} p_0 dv.$$

Taking account of the equation $pv = RT$ and the definitions of Q and of q, there exists between the two specific heats at constant pressure and constant volume.

The values of the heating of one molecule of gas and the knowledge of the numbers N of molecules disengaged by the combustion, enables us to translate into figures the equation (2). Further, this equation will give directly the heat of combustion sought for in degrees Centigrade; if we put

$$T_0 = 273\,;\quad T_1 = 0 + 273,$$

it becomes then

$$q = \Sigma N\left[\frac{a\theta}{1000} + \beta\frac{(\theta + 273)^2 - 273^2}{1000^2}\right]$$

in large calories, and we can solve it algebraically. But when we have to determine a great number of temperatures, as in this investigation, it is preferable to employ the following artifice:

Briefly, it consists in finding a positive value of θ, so that the number of calories expressed by Σ equals the number of calories q of the calorific power.

Arrange then the table of the heating of one gaseous molecule from 0° to 100, 200°C., etc., from 100 to 100° for example. Extend the Table to the perfect gases, to superheated steam, and to carbonic acid. This operation is easy by means of the formulas we have given. Further, the calculation can be very rapidly made; the squares

$$[T + 100]^2,\ [T + 200°]^2,\ [T + 300°],$$

etc., are immediately deduced, one from the other.

$$(Cp - Cv)(T_1 - T_0) = Ap_0(v_1 - v_0) = \frac{Ap_0 v_0}{273}(T_1 - T_0)$$

or between the molecular heats:

$$Cp - Cv = \frac{Ap_0 v_0}{273}$$

Taking as units the kilogram and the decimeter:

$$A = \frac{1}{E} = \frac{1}{4260},\quad p = 103{\cdot}33,\quad v_0 = 22300,\quad Cp - Cv = 1{\cdot}98$$

about two calories.

Perfect gases, $q = 6{\cdot}5\ \frac{T_1 - T_0}{1000} + 0{\cdot}6\ \frac{T_1^2 - T_0^2}{1000^2}$

Superheated steam, $q = 6{\cdot}5\ \frac{T_1 - T_0}{1000} + 2{\cdot}9\ \frac{T_1^2 - T_0^2}{1000^2}$

Carbonic acid, $q = 6{\cdot}5\ \frac{T_1 - T_0}{1000} + 3{\cdot}7\ \frac{T_1^2 - T_0^2}{1000^2}$

The numbers N, on the other part, being known, it is very evident that the table in question enables the value of the total heating of the residue of combustion (azote, carbonic acid, superheated steam), corresponding to 100, 200°C., etc.

Also, as we have always an idea approximately of the temperature sought for, it suffices to calculate the value of Σ for temperatures near θ, in order to determine the quantities of heat q_1 and q_2, such as

$$q_1 < q < q_2$$
$$\theta_1 < \theta < \theta_1 + 100.$$

The temperature sought for is comprised between θ and $\theta_1 + 100$, it differs from θ_1 by a quantity E, $\theta = \theta_1 + E$. Now E is easily calculated with sufficient precision.

In fact, between θ and $\theta_1 + 100$ there can be admitted that the increase of the temperature is proportional to the increase in the quantity of heat, and that, in this interval, 1 calorie corresponds to an augmentation of temperature:

$$\frac{100}{q_2 - q_1}.$$

E,* which corresponds to an increase of heat $q - q_1$, is, under these conditions, represented by

$$(q - q_1)\ \frac{100}{q_2 - q_1}$$

and the approximate value of θ is

$$\theta = \theta_1 + (q - q_1)\frac{100}{q_2 - q_1}.$$

The solution is not rigorous, but a greater exactness is useless.

A further reproach to this method of determination is that it does not take into account the dissociation of the superheated steam and of the carbonic acid. Regarding this objection, however, there may be stated that the dissociation of the superheated steam between 0° and 2,500° has a negligible influence. The effect of the dissociation of the carbonic acid is, also, practically but little sensible up to 2,000°, a temperature near which are grouped the most

part of the numbers that I give later on. Two of these numbers are near 2,500°, and it is proper to say that the coefficients of dissociation of the carbonic acid seem to have a real importance in the neighborhood of that temperature.*

Table of the Heatings in Calories.

The table of the heatings of the molecular volume of the gases is a useful document for many purposes. I think it beneficial to publish the one which I have used; its figures

HEATINGS IN CALORIES OF THE MOLECULAR VOLUME OF GASES FROM 0° C. TO 3,000° C. (UNDER CONSTANT PRESSURE.)

The molecular volume corresponds to 22·32 liters. The molecules are represented by the symbols Az^2, O^2, H^2, CO, CO^2.

Temperatures.	Azote, Oxygen, Oxide of Carbon, Hydrogen.	Superheated Steam.	Carbonic Acid.	Temperatures.	Azote, Oxygen, Oxide of Carbon, Hydrogen.	Superheated Steam.	Carbonic Acid.
0° C.	0·00	0·00	0·00	1,600° C.	12·46	20·35	23·09
100	0·68	0·83	0·87	1,700	13·34	22·13	25·18
200	1·39	1·73	1·85	1,800	14·23	23·93	27·31
300	2·10	2·67	2·87	1,900	15·14	25·83	29·55
400	2·82	3·69	3·99	2,000	16·05	27·76	31·83
500	3·56	4·76	5·17	2,100	16·98	29·74	34·18
600	4·31	5·89	6·44	2,200	17·92	31·81	36·64
700	5·07	7·07	7·77	2,300	18·87	33·91	39·14
800	5·85	8·30	9·16	2,400	19·84	36·10	41·75
900	6·63	9·62	10·66	2,500	20·81	38·32	44·40
1,000	7·43	10·98	12·12	2,600	21·80	40·62	47·16
1,100	8·24	12·40	13·85	2,700	22·80	42·95	49·96
1,200	9·05	13·87	15·55	2,800	23·82	45·37	52·87
1,300	9·89	15·41	17·33	2,900	24·84	47·82	55·81
1,400	10·73	17·00	19·18	3,000	25·88	50·35	58·86
1,500	11·59	18·65	21·11				

* The coefficient of dissociation is the proportion of the gas dissociated to that which would exist if the decomposition were complete. For carbonic acid, and at 2,500°, these coefficients are approximately 0·2 (pressure of 1 atmosphere), 0·4 (pressure of $\frac{1}{10}$ of an atmosphere), etc.

See Experimental Researches on Chemical Equilibriums, by Le Chatelier, "Annales des Mines." 1888.

have been carefully collated, and it is more extensive and nearer complete than the most part of those heretofore published.

III. Examples of Determination of Heats of Combustion.

Our hypotheses suppose that the combustibles are burned under the normal atmospheric pressure and with the aid of air, at the temperature of 0° C.

One hundred volumes of air decompose into about 80 volumes of azote and 20 volumes of oxygen. Consequently, if a molecular volume of oxygen, O^2, is necessary for the burning of a certain combustible, the gas resulting from the operation will comprise, specially, 4 molecular volumes of azote or $4Az^2$.

In order to commence, take the simplest case, that of the combustion of hydrogen.

(1) *Temperature of Combustion of Hydrogen.*—According to the above conventions, the combustion of hydrogen in cold air will be expressed as follows:

$$H^2 + \frac{O^2}{2} + 2Az^2 = 2Az^2 + H^2O, \text{ gas, } + 58{\cdot}2 \text{ calories.}$$

The residue of the combustion of 1 molecule (or 2 grams) of hydrogen comprises, then, 2 molecules of azote and 1 molecule of vaporized water. The heat disengaged by the reaction is 58·2 calories $= q$.

By referring this to the table of molecular heatings, there are easily obtained the values of Σ at about the anticipated temperature θ of combustion.

Heating at	1,800°	1,900°	2,000°
Of 2 molecules of azote,	$2\times14{\cdot}23 = 28{\cdot}46$	$2\times15{\cdot}14 = 30{\cdot}28$	$2\times16{\cdot}05 = 32{\cdot}10$
Of 1 molecule of steam,	$= 23{\cdot}93$	$25{\cdot}83$	$27{\cdot}76$
	$52{\cdot}39$	$q_1 = 56{\cdot}11$	$q_2 = 59{\cdot}86$

The temperature sought for is, then, between 1,900° and 2,000° C., corresponding respectively to the heatings in calories 56·11 and 59·86. Finally, we have, by applying the formula established above and taking account that $q = 58{\cdot}2$ calories,

$$\theta = 1900 + (q - q_1)\frac{100}{q_2 - q_1} = 1900 + 2{\cdot}09\ \frac{100}{3{\cdot}75} = 1956° \text{ C.},$$

or, in round numbers, 1960° C.

We should find for the oxide of carbon, very approximately, 2,100° C., the flame of oxide of carbon is, then, hotter than the flame of hydrogen.

(2) *Temperature of the Combustion of a Peat.*—Analysis of 100 grams of the specimen remaining after abstraction of ash and hygroscopic water:

Carbon	57·21
Hydrogen	5·69
Oxygen and azote	37·10
	100·00

Calorific power, water vaporized, 5,590 calories, corresponding for 100 grams to 559 calories.

The gases resulting from the combustion of 100 grams, in air, of this peat, comprise carbonic acid, water vaporized, and azote, of which the above analysis permits the determination of the number N of molecular volumes.

The proportion of carbonic acid is deduced from its tenor in carbon; as we know that 12 grams of carbon give, in burning, a molecular volume of carbonic acid, there will be in the gases of combustion

$$\frac{57{\cdot}21}{12} = 4{\cdot}76$$

volumes of carbonic acid.

Similarly, since 2 grams of hydrogen produce a molecule of water, the proportion of water vaporized will be

$$\frac{5{\cdot}69}{2} = 2{\cdot}84$$

volumes.

To calculate the azote, it is necessary to proportion it to the quantity of oxygen strictly utilized for the combustion.

	Volumes of Oxygen.
Now with 4·76 volumes of carbonic acid there are combined	4·76
And with 2·84 volumes of water vaporized there are combined	1·42
Total	6·18

Deducting from this sum the corresponding volume of oxygen pre-existing in the peat

$$\left(\frac{37{\cdot}10}{32} = \right) 1{\cdot}16,$$

and neglecting the small quantity of azote which accompanies this body in the peat, it becomes 6·18 — 1·16 = 5 02, or about 5 volumes. Five molecular volumes of oxygen are then necessary to burn the peat in question; these 5 volumes correspond to 25 volumes of air containing 20 volumes of azote which pass unchanged into the gases of combustion.

To sum up: The residue of combustion will have the following composition in molecular volumes:

Azote	20·00	volumes.
Vaporized water	2·84	"
Carbonic acid	4·76	"
	27·60	"

Possessing thus the numbers N of gaseous molecules, we determine in the following manner the values of Σ in the neighborhood of the temperature of combustion sought for:

Heatings at	1,900°	2,000°	2,100°	2,500°	2,600°
Of 20·00 volumes of azote	302·80	321·00	339·60	416·20	436·00
Of 2·84 volumes of steam	73·35	78·83	84·46	108·80	115·40
Of 4·76 volumes of carbonic acid	140·65	151·51	162·69	211·34	224·50
	516·80	$q_1 = 551·34$	$q_2 = 586·75$	736·34	775·90

As, on the other part, $q = 559$, the temperature of combustion sought for is visibly placed between 2,000° and 2,100°. We have, finally, with very close approximation,

$$\theta = 2000 + (559 - 551)\frac{100}{587 - 551} = 2020° \text{ C.}$$

The values above of the heatings at 2,500° and at 2,600° enable an idea to be had of the influence that would be exerted on the value of the flame by the previous heating of the air to 1,000° for example. In this hypothesis, the quantity q would be formed not only of the number of calories due to the heat of the combustion, but also of the number of calories carried by 25 volumes of air heated to 1,000°, $q = 559 + 25 \times 7·43$; according to the table of the heatings $q = 559 + 186 = 745$ calories. Completing the calculation we find $\theta = 2{,}520°$. The previous heating of the air to 1,000° has raised the temperature of combustion about 500° C.

(3) *Temperature of Combustion of a Coal.*—Take, for example, the coal of Treuil (St. Etienne).

The elementary analysis of this coal has given abstraction made of ash and hygroscopic water:*

Carbon	89·23
Hydrogen	5·03
Oxygen and azote	5·74

Supposing the water resulting from the combustion to be vaporized the calorific power is 8,580 calories.

The method of calculation employed for the peat is here applicable without modification. We find, notably in the gaseous residue, the following composition in molecular volumes:

Azote	34·00
Superheated steam	2·50
Carbonic acid	7·40
Total	43·90

corresponding to 42·50 volumes of air used in the combustion.

Value of the flame (cold air)	2,010°
Value of the flame (air at 1,000°)	2,570°

I add that the reader will find other examples, notably in what concerns gaseous combustibles, in Mr. Damour's book already cited.

IV. Results of Calculations.

I have applied the preceding method to the calculation of the value of the flame of a certain number of combustibles. In order to render more easy the comparison of the results, I have supposed these combustibles to be deprived of their ash and hygroscopic water.

I have taken the elementary analyses and the calorific powers from pages 54, 59 and 80 of my work, entitled "Etudes sur les Combustibles." The following table gives the figures obtained.

The value of the flame varies very little from one combustible to another. The mean of sixteen enumerated is 1,986°, and it seems that the round number 2,000° can be adopted as representing the theoretical temperature of com-

* Combustibles, such as coal and peat, always contain a certain quantity of hygroscopic water which passes entirely into the gases of combustion. It is very easy to take account of this water in the calculation of the temperature.

bustion of any combustible whatever of vegetable origin. As absolutely rigorous constants could not be obtained for the process I have described, a more precise number is useless.

Designation of the Combustibles.	Calorific Power.		Value of the Flame.
	Water Condensed.	Water Vaporized.	
	Calories.	Calories.	Centigrade Degrees.
Oak from Lorraine	4,690	4,370	1,865
Peat from Bohemia	5,900	5,590	2,020
Lignite from Trifail	6,650	6,370	1,960
Flaming coal from Blanzy (Ste. Marie)	8,350	8,060	1,990
Flaming coal from Decazeville (Tramont)	7,840	7,530	1,960
Oxidized coal from Commentry	6,380	6,200	1,960
Gas coal from Commentry	8,410	8,110	1,950
Gas coal from Béthune	8,670	8,380	1,990
Gas coal from Lens	8,740	8,450	2,010
Fat coal from St. Etienne (Treuil)	8,860	8,580	2,010
Marechale coal from Roche-la-Moleire	8,860	8,600	2,030
Semi-fat coal from d'Anzin (St. Marc)	8,660	8,430	1,980
Anthracitic coal from Commentry	8,460	8,290	2,030
Anthracitic coal from Kebao	8,530	8,370	2,020
Anthracitic coal from Creusot	8,690	8,480	2,010
Anthracite coal from Pennsylvania	8,366	8,140	2,000

The value which, in the above table, is the farthest from the mean of 2,000°, is that of oak—1,865°.

The temperatures which are the farthest removed in excess from the mean 2,000° are, in general, those of the anthracitic coal. The popular opinion has always been that anthracite has a hotter flame than coal. The relative value of the flames sustains this opinion.

To the results in the above table can be added those which I have found for different liquid combustibles, as follows:

Ethylic alcohol and methylic alcohol . . . . . 1,700°
Amylic alcohol . . . . . 1,850°
Crude American petroleum . . . . 2,000° (calorific power, 10,400.)
Essence of American petroleum . . 1,910° (calorific power, 10,270.)
Refined American petroleum oil . . 1,660° (calorific power, 10,280.)

Finally, below will be found the temperatures of combustion of several gases under constant pressure.

Hydrogen	1,960°
Oxide of carbon	2,100°
Methane	1,850°
Acetylene	2,350°
Illuminating gas, mean *	1,950°
Water gas, industrial	2,000°

An examination of the numbers grouped in this work shows the apparently paradoxical appearance that of two combustibles, the one having the greatest calorific power is not necessarily the one having the hottest flame.

The flame of the essence of petroleum is relatively cold. The flame of the sample of peat appears hotter than that of the coal of the Treuil, the calorific power of which is excellent. The flame of the oxidized coal from Commentry is a little better than that of the same coal not deteriorated.

Moreover, everything occurs in all cases and, notably, for the combustibles of vegetable origin, as if the elements of the temperature of combustion, calorific power, elementary composition, volume and composition of the gases of combustion, compensated each other so as to give to all the combustibles flames of very nearly the same thermometric degrees of temperature.

This, however, does not lessen the advantages due to the high calorific power of good coals, and which is the true measure of their value, since the flame utilizable of a coal is a great deal more voluminous than that of a peat, a very much oxidized matter, the combustion of which requires but very little air.

We have seen, for example, that the combustion of 100 grams of Bohemian peat corresponds to the disengagement of 28 volumes of gases of combustion at 2,000°, while the gaseous residue of the coal from the Treuil attains 44 units † at the same temperature.

OCTOBER, 1903.

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* According to Mr. A. Sainte-Claire Deville ("Société Technique de l'Industrie du Gaz," 1903.)

† The use of hot air for improving the flame, from the thermometric point of view, is certainly more efficacious in the furnaces in which coal is burned than in those in which an inferior combustible is burned.

ELECTRIC SMELTING OF IRON ORES.

This subject has recently been made the subject of investigation by an expert commission appointed by the Canadian Government, whose study of the subject was directed particularly to the question as it affected the iron-ore deposits of Canada. The commission made a tour of the best-known electric iron-smelting furnaces in Europe, and its findings have been embodied in a report which has recently been issued by the Canadian Department of Mines. Its conclusions are summed up in the statement that pig iron can be produced on a commercial scale, at a price to compete with the blast furnace, only when electric energy is very cheap and fuel very dear. It was found that on the basis assumed in the report, with electric energy at $10 per electric horse-power year, and with coke at $7 per ton, the cost of production is the same as the cost of producing pig iron in a modern blast furnace. Under ordinary conditions, where blast furnaces are an established industry, electric smelting cannot compete; but in special cases, where ample water power is available and blast-furnace coke cannot be readily obtained, electric smelting may be commercially successful. On the other hand, although the cost of electric ore reduction prevents it from competing with either the Bessemer or the Siemens open-hearth process in the production of the common grades of commercial steel, the process was found to be in successful commercial use in the production of high-grade crucible steel.

Now the report of this commission, outside of having fulfilled the immediate purpose for which it was presented, should serve as a safeguard to the general public against being led into hasty and undigested schemes for the smelting of iron ore. The figure of $10 per electric horse-power year can only be realized under very exceptional circumstances, where water is abundant, readily available and contiguous to large deposits of iron ore. We believe that the lowest figures obtainable at Niagara are from $15 to $20 per horse-power, and here, because of the size of the plant, and the unlimited volume and great head of water available, the conditions are ideal for cheap production. It may be that some of the large plants which, during the past few years, have been hurriedly erected on a scale far beyond the immediate local demand for power, are making contracts at prices that give very little, if any, return on the investment; and great care should be exercised in using such low figures as a basis of indiscriminate estimate of the cost of electric iron-ore reduction.—*Scientific American.*

RHINE-DANUBE SHIP CANAL.

A ship canal to connect the Rhine and the Danube, which will have a total length of 181½ miles, has been proposed. The cost is estimated at about $35,000,000, of which $10,000,000 would be absorbed by the canalization of the River Neckar, which is one feature of the scheme. It is thought, however, that an asset value of $6,000,000 or $7,000,000 would accrue from the water power of the various locks. The length from Mannheim on the Rhine to Neckarems on the Neckar is 110 miles, and thence to the Danube is 71½ miles. This canal would place the now more or less isolated kingdom of Wuerttemberg in the middle of the largest and most important waterway of Europe.

CHEMICAL SECTION.

Stated Meeting, held Thursday, November 10, 1904.

Salt-Making in the Far-West.

By E. Goldsmith.

By reason of the cost of transportation across the continent, table salt, on the Pacific Coast, at one time was rather high in price.

It seems, according to information obtained in Salt Lake City, Utah, that the Mormons were the first who found rock salt about seventy miles away from their settlement near the Great Salt Lake.

Although there was plenty of salt in the lake, they preferred, for certain reasons, unknown to the writer, to haul their salt supply from the deposit in the Wasatch Mountain.

It follows, therefore, that the people in Utah and adjacent territories were not dependent on the Eastern States for their supply of table salt. It appears, however, that the earlier settlers on the west coast of North America drew at least a part of their supplies of salt from the Eastern States until they began to see a margin in the winning of the salt from the waters of the Pacific Ocean. The fact is, as the writer learned in a recent visit to the Pacific Coast, that salt-making, as they called it, is a thriving industry there at the present time.

The long dry season of about eight months or longer during the year, favors the winning of salt from the ocean in a high degree.

Cheap and flat land a few feet above the sea level, away from human habitations and not approachable by cattle or the sheep herder, to avoid contamination and other troubles, is best suited for the salt industry.

Of course, it requires some preparation of the land. Let us imagine a five or ten acre lot of ground to be prepared to form an evaporating pan.

It seems that, after some leveling with pick and shovel, wooden boards are driven into the sand to form the sides of the pan. Now, they cover the boards all around with the sand from within, forming on both sides a slope. The height is about 10 to 12 inches. I was told that some parties used no boards at all, that the triangular elevation or rim of sand would hold without an internal board. These tapering sides of the large level sand pan are strong enough, so long as no storm is raging, because there is not much pressure against them.

We have now an earth- or sand-evaporating pan for salt-making from ocean-water, or from the water of the Great Salt Lake of Utah.

To do the work on a large scale it is only necessary to multiply the number of such earth or sand pans, so as to have, say, a thousand acres or more of surface to be filled with the brine and let the solar heat do the work of evaporating the water, when in due time the salt, after sufficient concentration, will crystallize in cubes and collect at the bottom of the pan.

They usually fill these huge earth pans to about 6 inches, more or less, with the salty water by using comparatively small steam pumps. A small wooden shanty is seen at various locations in the salt plant, usually at a corner, in such a position that a number of pans may be filled and refilled with the same steam pump.

I have not noticed any provision of a general reservoir from which all the earth pans receive their filling with the brine through a system of pipes. It appears, therefore, that the salt-water is raised for each sand pan separately; but there exist also connections between the pans whenever they are on the same level. After a certain number of days, when the water has in part disappeared, the filling is repeated, and so on until a good heavy crop of crude salt covers the bottom of the pan.

The crude salt is now ready to be collected. It is the custom to pile it into quadrangular masses, usually on one of the longer sides of the earth pan. In the scraping of the salt into a pile the workman must avoid the sand, and,

therefore, scrapes gently over the layer in such a manner as to leave a thin crust of salt on the sandy bottom of the pan. The piles of crude salt, many tons in weight, are now allowed to drain for some time, and the mass is then ready to be transported to the refining house. For this purpose the crude material is loaded on freight cars conveniently at hand. Without such transportation facilities, it will be manifest that the cost of labor for hauling to the refining plant might absorb the profits and cause the failure of the enterprise.

Now, in Europe the refining of sea or lake salt is generally effected by a system of fractional crystallization, washing and drying the product; that is to say, from the original brine direct, and not by a re-solution of the crude salt and re-crystallization as is the general practice and requirements in other similar chemical processes.

The French salt producer on the Atlantic Coast watches with care the concentration of the brine and observes the formation of the pellicles of salt forming and floating on the surface of the mother liquor. These small crystals of salt are considered the purest and, therefore, of the best quality that can be obtained under those conditions. It constitutes the table salt of the people of France and is considered to be a satisfactory market product. But it must not be supposed to be chemically pure; it is rarely better than 97 per cent.; and if occasionally it is found to be a little better, it is exceptional.

Generally speaking, the percentage of the pure salt is below 97 per cent., and sometimes it is found in the market as low as 90 per cent. The second and third crops of salt are utilized for industrial purposes.

In Utah and California an entirely different method of refining the crude salt has been developed.

The method adopted there—in the Far West—may be termed "the dry refining of salt."

As has been indicated above, no notice is taken of a first, second, or third crop of crystal salt in the sandy earth-pans by our Western salt producers. On the contrary, they allow the crop of salt to grow as much as possible;

rake it together, let it drain, and refine it by their own dry method.

This dry method of refining table salt is based on the following conditions:

(1) We have a mixture of anhydrous sodium chloride and two hydrated magnesium salts, to wit: magnesium sulphate and magnesium chloride; sometimes also calcium chloride and sulphate of sodium is present.

(2) If these two magnesium salts are removed, it is self-evident that the residue will be pure table salt (NaCl).

(3) If this mixture of salts be heated and all the water of crystallization contained therein be driven off, the magnesium salts are converted to a fine, pulverulent condition which may be removed by a current of air. Experiments have fully proven the correctness of this method. I am sorry to say that the name of the inventor of the process has not been disclosed. However, from data obtained in California and in Salt Lake City, Utah, I am satisfied that the Mormons exploited the first plant for refining table salt on a large scale by the dry process.

The refining process carried on at the work near Salt-Air, Utah, is a continuous one. A slowly rotating cylinder, apparently made of wood, about 30 feet long and roughly estimated about 6 feet in diameter, is caused to make about one revolution in four or five minutes. In the inner part of this cylinder is fixed an iron cylinder about 12 or 16 inches in diameter, which is charged, as I am informed, with superheated steam, supplied and connected by the necessary coil and steam generator. This is the dryer.

The salt, in the wet state, is fed into the hottest end of the dryer by a screw carrier, made of iron. Within this long cylindrical dryer it is slowly moved forward towards the other end by means of an arrangement that keeps the layer of salt evenly and thinly spread over the whole length of the dryer. The water is thus vaporized and carried off through a flue urged with the aid of an exhaust fan driven at considerable speed. The exhaust fan which carries off the vapor of water at the same time carries with it the now fine dust of the two magnesium salts; thus doing double service.

At the further end of the cylinder the dry hot salt falls upon a sieve, where another separation takes place, namely: all of the material that has formed into lumps is caught upon the sieve. On taking a sample of the sifted salt from the receiving box the salt felt quite hot. Looking critically upon the small crystals I saw that there was still some little of the white dry powder adhering to them, indicating that the magnesia salts had not been entirely removed. I made the remark to the guide (one of the workmen) who showed me through the works, that the separation was not complete; and he acknowledged the fact that by one blowing—as he termed it—the separation of the impurities could not be completely effected, but that a second and third grinding and sifting and blowing was required to finish the salt for table use.

The successive transportations of the material were effected as in a flour-mill, by horizontal and vertical belts on which triangular boxes were fixed to receive and carry the salt to another point. To avoid any contamination, through dust or dirt, the entire system of belt carriers was run in quadrangular wooden boxes well fitted together.

The best grade of salt, for table use, is ground very fine; and it is not possible to recognize the presence of any of the magnesium salts without a chemical analysis. I did not take along a sample for chemical examination, and hence withhold judgment with regard to the perfect separation of the magnesium salts from the sodium chloride for table use produced at the Works of Salt Air. So far as appearances go the article was good and had no bitter taste. Whether the salt will keep dry in a moist atmosphere is a question I am unable to answer. I saw some samples of salt from the Pacific Coast at the St. Louis Exposition which showed signs of moisture to some extent. While there I tried to find samples of salt from Salt Air, Utah, but without success. My object was, of course, to observe what effect, if any, the moist atmosphere of St. Louis would have upon the product.

I could hardly believe it possible that all the magnesium salts could be removed from chloride sodium by the dry

process; but it seems that the article is at least as good as the French, and that suffices. At any rate, the material is produced in the West on a very large scale, considering the population.

The output is from 150,000 to 200,000 tons annually, which is far in excess of what is needed for home consumption. It is even exported to the Hawaiian Islands and other points. It is accepted by the consumer as satisfactory, and that proves better than any other criticism that the dry process of refining table salt is an accomplished fact.

The current of forced air which drives the dry, dusty magnesium salts away from the sodium chloride along with the vapor of water carries with it some of the sodium chloride. This is shown by the fact that on top of the building, near the flues, there is a fairly thick, white deposit of the mixed salts, which would run down the roof if much moisture were in the air.

In the Salt Air Works this separated mixture of salts is not thrown away, but is made available by mixing it with about one-fifth its weight of sulphur and heating the mass to form blocks. These keep fairly dry and are sold to the dairymen and cattle raisers as lick-salt. It finds a market, and my informant told me that the demand for it was greater than the supply.

SUBMERGED COAL EXPERIMENTS.

Some time ago we drew attention to the experiments that were being carried out by the British Admiralty with submerged coal. In May, 1903, five crates of coal, each holding two tons, were sunk in a basin at Portsmouth, and a similar quantity was placed at the coaling point on land, in small heaps, covered with tarpaulins. Six months ago some of the submerged coal was raised and burnt, in conjunction with a similar quantity of that which had been kept on land, and the results showed that the submerged coal had greater calorific qualities. Owing to the success of this test, further experiments are to be carried out on the same basis.—*Scientific American*.

STEEL RAILWAY TIES.

Officials of the Lake Shore Railroad have placed an order for 7,000 steel ties to be used as an experiment, probably near the eastern terminus of the road at Buffalo. Part of the order will be used on the New York Central, and if the results are satisfactory it is expected that a more general use of steel ties will be made by the Vanderbilt roads.

Mechanical and Engineering Section.

(*Stated Meeting held November 25, 1904.*)

The United States Patent Laws: Historically and Practically Considered.*

By Cyrus N. Anderson,
of the Philadelphia Bar.

Several years ago a writer in the *Iron Industry Gazette*, an English publication, said: "Disparagement of patents is common and easy, but it should not be forgotten by those who sneer at inventions that, out of a total of eight billions of capital invested in manufacturing in the United States, patents form the basis for an investment of about six billions. Evidently, the United States system of encouraging invention that has resulted in the patenting of over 500,000 inventions is a system which is exceedingly wise and valuable. The only thing that has enabled manufacturers to make so wonderful a progress in the United States is its patent system."

Up to the present time, there have been granted in the United States nearly 800,000 patents, and, while I have no recent figures, there is no doubt but that the proportion of capital invested in manufactures with patents as a basis is as great, if not greater, now than it was when the foregoing statement was made.

At a time when the right of property in patents, or rather in patented inventions, is so well recognized, it strikes one as a curious fact that there ever was or should have been a time when a right to such property was not recognized. Yet the fact is that in comparatively recent periods, considered in the light of the world's history, property rights in connection with inventions were not recognized, and if a man was possessed of an inventive turn of mind and was an

* Read at the stated meeting of the Business and Professional Club for November, 1904, and (by title) before the Mechanical and Engineering Section of the Institute, November 25, 1904.

inventive genius, and made inventions or improvements in machines or in mechanical devices or in the art of doing things, he had to stand by and see others enjoy equally with him the benefits of his intellectual thought and effort.

In the very earliest history, the right of property in tangible things was recognized, but an exclusive right in intellectual property, such as inventions and writings, was not regarded as a natural right, and the right to such property was only established as a result of advancing and improved civilization.

It seems that quite early in England the practice grew up under which the Crown, as a matter of grace and favor, but not of right, granted to the inventor of a new manufacture or a new art, the exclusive right for limited periods to his invention or improvement, and it is reported that in the fourteenth century, in the reign of Edward III, some wise subjects of the realm, alchemists they were, invented or discovered a philosopher's stone. A commission was appointed by the King, consisting of two aldermen and two friars, who, after an investigation, which, of course, was very carefully made, reported that the philosopher's stone possessed merit, and upon this report the King granted an exclusive right to the discoverers to manufacture and sell the philosopher's stone.

When the nature of intellectual property is considered, it seems somewhat anomalous that rights of property therein should not have been recognized from the very earliest times.

Professor Shaler has said: "When we come to weigh the rights of the several sorts of property which can be held by men, and in this judgment take only the absolute questions of justice, leaving out the limitations of expedience and prejudice, it will be seen clearly that intellectual property is after all, the only possession in the world. The man who brings out of nothingness some child of his thoughts has rights therein which cannot belong to any source of property."

Mr. Fessenden, in his work on patents, published in 1821, says: "In a moral as well as in a political point of view,

the author of a new and useful invention has the best of all possible titles to a monopoly of the first fruits of his ingenuity. The invention is the work of his hands and the offspring of his intellect; and after he is allowed a temporary monopoly, becomes at the expiration of the patent a valuable donation to society."

At least as early as about the year 1600 the right of property in invention was well understood and had a well-established and defined standing in the common law. As indicating that in the common law of England at that time the reason for granting exclusive privileges to inventors, and that the rights of property in inventions were fairly understood, I will read you what was said by the Court in the case of Darcy *vs.* Allin: "Where any man, by his own charge and industry, or by his own wit or invention, doth bring any new trade into the realm, or any engine tending to the furtherance of a trade that was never used before; and that for the good of the realm: that in such cases the King may grant to him a monopoly patent for some reasonable time, until the subjects may learn the same, in consideration of the good that he doth bring by his invention to the commonwealth; otherwise not."

Sir Edward Coke said of patent privileges that: "The reason wherefor such a privilege is good in law is because the inventor bringeth to and for the commonwealth a new manufacture by his invention, costs and charges, and therefore it is reason that he should have a privilege for his reward (and the encouragement of others in the like) for a convenient time."

It does not appear that there was any statutory law passed in England concerning the patenting of inventions until the year 1623, in the twenty-first year of the reign of James I, at which time the statute of monopolies was passed, which declared certain monopolies to be void, and prohibited the grant of such monopolies in the future. One section of this statute, however, related to patents and read as follows:

"Provided also, and be it declared and enacted: That any declaration before mentioned shall not extend to any

letters-patent and grants of privilege, for the term of fourteen years or under, hereafter to be made, of the sole working or making of any manner of new manufactures, within this realm, to the true and first inventor and inventors of such manufactures, which others, at the time of making such letters-patent and grant, shall not use, so as also they be not contrary to the law, nor mischievous to the state, by raising prices of commodities at home, or hurt of trade, or generally inconvenient: The said fourteen years to be accounted from the date of the first letters-patent or grant of such privilege, hereafter to be made: but that the same shall be of such force as they should be, if this act had never been made and of none other."

I quote this section of the statute in full because it is the first English statute on the subject, and is the very foundation of our own laws on the subject of patents. These laws are the result of development and evolution.

Mr. Robinson, the author of one of our most elaborate treatises on the subject of the patent laws, has said that in this statute, as interpreted by the English courts, are found the sources of the patent laws of the United States.

The 150 years following the statute just referred to covered the Colonial period of the United States. During that period of our existence there was, as is well known to all, very little manufacturing within the present borders of the United States, and very little improvement in the manufacturing arts was made by the Colonists. The country was very thinly and sparsely settled; the Colonists, our forefathers, had duties to perform which were much more pressing upon them than the making of inventions or improvements in the method or art of doing things in the manufacturing world. The Colonists were making a continual fight for existence and constant effort to subdue the many obstacles incident to the development of a new country, and had no time to engage in the fascinating and frequently profitable pursuit of making improvements and inventions in existing devices in the manufacturing arts.

It is not surprising that under these conditions the Colonists made few inventions. But there was still another

obstacle in the way of improvement by the Colonists of the manufacturing arts. This obstacle was the attitude of England toward the Colonists upon this matter. It was England's idea that the Colonists should supply raw articles of commerce, such as the products of the farm, and that England should furnish to the Colonists all such manufactured articles as might be needed or demanded by the Colonists. England's policy toward the Colonists was expressed by Sir William Pitt, when he said: "It is the destiny of America to feed Great Britain, and the destiny of Great Britain to clothe America." Lord Chatham said, "I would not allow the Colonists to make so much as a hob nail for themselves."

Laws were enacted by England prohibiting every species of manufactures in the Colonies. When the Colonists began to make iron and nails for their use, the House of Commons resolved that "none of the plantations should manufacture iron nails of any kind out of any sows, pigs, whatsoever." And the House of Lords added, "No forge going by water, or other works, should be erected in any of the plantations for the making, working or converting of any sows, pigs, or cast iron into bar or rod iron."

By an act of 1750 the erection of buildings and mills for making iron was prohibited. There were corresponding restrictions imposed upon the Colonies with respect to all sorts of manufacturing arts. For instance, in 1684, Virginia passed an act encouraging the manufacture of the textile fabrics which was annulled by Parliament. The condition of manufactures in the Colonies has been well set forth by Senator Thomas C. Platt, of Connecticut, as follows:

"Manufactures were practically unknown; . . . there were no machines as we now understand the term; . . . men knew how to plough and sow, hoe and chop, reap, mow and cradle, break flax and hackle it, thresh with the flail, winnow with the blanket or fan and to shell corn by hand. The women knew how to spin, card, weave and knit. Mechanical knowledge was monopolized by the blacksmith, the carpenter, the millwright and the village tinker. Pro-

duction was a toilsome, weary task, limited by the capacity for muscular endurance."

It is probable that the first patent granted within the limits of the United States was by the general court of the Colony of Massachusetts, under date of May 6, 1646, to one Joseph Jenckes, of Lynn, for a scythe. In his petition or prayer, he prayed for protection for "Fowerteen yeeres, without disturbance by any other setting up the like inventions, so that his study and cost may not be in vayne or lost."

Before proceeding to a discussion of the laws relating to patents which have been enacted by the United States Government, I desire to call attention briefly to some of the objections which have been made to patents. The objection has been made that there is no such thing as intellectual property, and that ownership of such property restricts common rights. Also that the granting of a patent is a creation of a monopoly. Patents have been compared to letters of marque, which allowed the holder to prey upon honest industry. It has been urged that patents increase the price of commodities, and that they encourage labor-saving inventions and take opportunities from the artisan.

It is needless to say to an audience of the present day that the last objection is utterly without foundation. Exactly the reverse has been proved adequately. It has been urged that patented inventions reduce or sink man to automata, and that the granting of a patent enables one man to say to another that he shall not carry on his business in the best way, and that by granting a patent the idea involved in the patent is tied up, and the course of thought in that direction is stayed. A Frenchman has advanced a picturesque objection that patents give undue advantage to their possessor by "making a golden bridge for him who enters the arena with arms more subtle and more finely tempered than those of his adversaries."

The foundation of all the patent-law legislation in the United States is the clause or phrase in the Constitution which vests in Congress power "to promote the progress of science and useful arts by securing for limited times to

authors and inventors the exclusive right to their respective writings or discoveries."

The first patent law of the United States was enacted in the year 1790, April the 10th. It followed in a general way the law then in existence in England authorizing the grant of patents without an examination of the prior art, as is now the case. The authority to grant patents was conferred upon the Secretary of State, the Secretary of War and the Attorney-General of the United States.

It appears that Mr. Jefferson, who was at that time Secretary of State, took great interest in the patent laws, and regarded them and the granting of a patent as of the very greatest importance, and he is generally referred to as the Father of the United States Patent Laws.

In the Official Gazette of the United States Patent Office, published September 24, 1877, an interesting description of the early practice under the Act of 1790 occurs: "By Act of April 10, 1790, the first American Patent System was founded. Thomas Jefferson inspired it, and may be said to have been the Father of the American Patent Office. He took great pride in it, it is said, and gave personal consideration to every application that was made for a patent during the years between 1790 and 1793, while the power of revision and rejection granted by that Act remained in force. It is related that the granting of a patent was held to be in these early times quite an event in the history of the State Department, where the clerical part of the work was then performed.

It is a matter of tradition, handed down to us from generation to generation, by those who love to speak of Mr. Jefferson, his virtues and his ecentricities, that when an application for patent was made under the first Act, he would summon Mr. Henry Knox, of Massachusetts, who was Secretary of War, and Mr. Edmund Randolph, of Virginia, who was Attorney General—these officers being designated by the Act, with the Secretary of State, a tribunal to examine and grant patents—and that these three distinguished officials would examine the applications critically, scrutinize each point of the specification and claims carefully and

rigorously. The result of this examination was that during the first year, a majority of the applications filed failed to pass the ordeal, and only three patents were granted. In those days every step in the issuance of a patent was taken with great caution, Mr. Jefferson seeking always to impress upon the minds of his officers and the public that the granting of a patent was a matter of no ordinary importance."

It is not to be understood that the examination referred to an investigation of the prior art. The only examination required was of the petition, description, drawing, etc., of the application.

The next patent act was amendatory in its nature, and was passed in 1793. Among other changes, it imposed the duty of issuing patents upon the Secretary of State, subject, however, to the approval of the Attorney General.

From 1793 down to 1836, various unimportant amendments to the patent laws were enacted. In the last mentioned year, however, the first comprehensive law was passed relating to the grant of patents. This law remained in force until 1870, and was in fact in substance very much the same as our present laws.

By the enactment of 1836, a sub-department of the State Department was created, which was known as the Patent Office. Provision was made for the appointment of a Commissioner of Patents, and the Commissioner of Patents was required to make or to have made an examination of the alleged new invention or discovery to determine whether or not the same had been invented or discovered by any other person in the United States prior to the alleged invention thereof by the applicant and to determine whether or not, in view of the prior art, the applicant was entitled to a patent.

Prior to this Act examinations were not required, and if the applicant averred that his alleged invention was new and novel, the Commission or the Secretary of State was required to grant or issue a patent upon his application, provided the discovery or invention of the applicant was deemed of sufficient importance.

It will readily be seen that a patent granted under such circumstances was necessarily of very small commercial value, because it would not be reasonable to expect men to invest their capital in a species of property good title to which and the value of which were so uncertain.

The Act of 1836 established patent property upon a higher plane than it had ever before occupied and it is believed that the importance of this act to the people of the United States cannot be overestimated.

Senator Thomas C. Platt, speaking in 1884, referring to this Act, said:

"To my mind, the passage of the Act of 1836 creating the Patent Office marks the most important epoch in the history of our development—I think, the most important event in the history of our Government from the Constitution until the Civil War. The establishment of the Patent Office marked the commencement of that marvelous development of the resources of the country which is the admiration and wonder of the world, a development which challenges all history for a parallel; and it is not too much to say that this unexampled progress has been not only dependent upon, but has been coincident with, the growth and development of the patent system of this country. Words fail in attempting to portray the advancement of this country for the last fifty years. We have had fifty years of progress, fifty years of inventions applied to the everyday wants of life, fifty years of patent encouragement, and fifty years of a development in wealth, resources, grandeur, culture, power which is little short of miraculous. Population, production, business, wealth, comfort, culture, power, grandeur, these have all kept step with the expansion of the inventive genius of the country; and this progess has been made possible only by the inventions of its citizens. All history confirms us in the conclusion that it is the development by the mechanic arts of the industries of a country which brings to it greatness and power and glory. No purely agricultural, pastoral people ever achieved any high standing among the nations of the earth. It is only when the brain evolves and the cunning hand fashions

labor-saving machines that a nation begins to throb with new energy and life and expands with a new growth. It is only when thought wrings from nature her untold secret treasures that solid wealth and strength are accumulated by a people."

Under the patent laws now in force in the United States any person who has invented or discovered any new and useful art, machine, manufacture or composition of matter, or any new and useful improvement thereof, not known or used by others in this country before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than two years prior to his application, and not in public use or on sale in this country more than two years prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law and other due proceedings had, obtain a patent therefor.

It may be remarked here that the word "discovered" in this section of the statute means "invention."

It will be noted that foreigners have the same rights under this law as citizens of the United States.

The first requisite to the securing of a patent is the making of an invention. Just what invention is or what it takes to constitute an act of invention is a question that has been discussed by the courts and by text-book writers many, many times, and it is a question which cannot be answered by definition. I say this, notwithstanding that definitions of the term "invention" will be found in many text-books, and in many decisions of the courts. Suffice it to say that invention comprehends a new idea of means and it must be something beyond the scope of merely mechanical effort.

Having made an invention, the next step in the process of securing a patent consists in the preparation of an application and the filing of the same in the Patent Office. This application comprises a petition to the Commissioner of Patents, requesting the grant of the patent for the invention disclosed in the application, an oath answering to the

requirements of the statutes, a specification descriptive of the invention, and such specification must be concluded with a claim or claims specifically pointing out the improvement or invention. If no application has been made in a foreign country, the oath should set forth that the applicant is the original and first inventor of the invention disclosed in the application and described and claimed in the specification; that such invention was never known or used before his invention or discovery thereof; that such invention had not been patented or described in any printed publication in the United States of America or any foreign country before his invention or discovery thereof, or more than two years prior to his application; that the said invention had not been in public use or on sale in the United States for more than two years prior to his application, and that no application for foreign patent had been filed by him or his legal representatives or assigns in any foreign country prior to his application in the United States. If, however, applications for patents in countries foreign to the United States have been made at the time of the filing of an application in the United States, it is necessary for the applicant to name the foreign country or countries in which such applications have been made, giving the date of the filing of the same.

The claims are necessary to a complete specification. The specification must, of course, be signed by the applicant, who in nearly all cases is the inventor, and the application when forwarded to the Patent Office must be accompanied by the first Government fee of $15. Where the application relates to an invention which can be graphically depicted, it is necessary to prepare and file drawings with and as a part of the application.

If any one of the parts above referred to are omitted, the application will not be accepted by the Patent Office, and the same will not be filed until all of the parts have been received by the Patent Office.

After an application has been received by the Patent Office, it goes to the Application Division, where it is classified, and is then fowarded to the division in the Patent Office in which is to be found the class of machine or art to

which the invention belongs. Applications received in the office are examined in regular order, according to their filing dates.

Before the claims of an application are allowed, careful examination of the prior art is made, and only such claims are allowed as distinguish from the constructions disclosed by the patents and other publications discovered by the examiner in his search of the art.

As a rule these examinations are carefully made, though, as you will readily understand, where several hundred examiners and assistants are employed, some of them are more careful in their work than others. The more care taken in the search and examination of the records in the Patent Office, the more likely is it that the patented claims will be valid.

It frequently becomes necessary to amend the claims, perhaps many times, before they can be brought into such shape that they distinguish from the art.

There is one thing that should be understood by all applicants for patents, and that is that the claims of a patent are of the very greatest importance; in fact, I should regard the claims as the most important part of a patent. Unless the claims are well drawn and unless they cover well the invention forming the subject-matter of the patent, the patent loses much of its value.

The phraseology of the claims should be accurate. It is as necessary that the elements or parts entering into and forming the combination set forth in a claim should be stated and put together with exactness and precision as it is that the same elements be fitted together with exactness and precision in the machine itself.

As I have already said, the claims of a patent should be drawn with very great care, and should be made as accurate and as exact and as much to the point as it is possible.

I am sorry to say, however, that in many, many instances claims are vaguely and loosely drawn. This in some instances is due to a lack of knowledge of what the invention really is; in others it is a lack of ability to express ideas clearly in writing; in others it is perhaps a lack of effort;

and in others it is perhaps due to a lack of proper time; but whatever the cause may be, failure to secure good claims is a misfortune so far as the patentee is concerned.

A writer in *The Forum*, referring to the difficulty of claim writing, has said: "It takes a very experienced hand to avoid defects which will nullify the patentee's proper advantage. An omission is fatal; an addition is fatal; and a vagueness is fatal."

Broadly considered, the claims of an application may be divided into generic and specific claims. If the invention disclosed in an application will support a broad or generic claim, such a claim should by all means be included. But in addition to such claim, specific claims also should be included because it is very much easier to anticipate a broad claim in the prior art than it is to anticipate a specific claim, and it may happen, if the claims of the patent are ever subjected to litigation, that the patentee would be able to sustain the validity of the specific claim but would be unable to sustain the validity of the generic claim. In such case, the patent, by reason of the presence of the specific claim, would still be of value to the patentee, while, on the contrary, if it had included only the generic or broad claim or claims, which had been anticipated, the value of the patent would be entirely destroyed.

It is not always so, but, generally speaking, a broad claim includes a small number of elements in combination, while a specific claim will include a greater number of elements in combination, and these elements may be still further affected and narrowed by qualifying limitations.

It sometimes happens that an inventor, who fully understands the details and principles of his invention, concludes that he is better fitted to write his specification and claims, that is to say, is better fitted to prepare his application for the Patent Office than some one who has had experience in the writing of specifications and the drawing of claims, and therefore undertakes to do this work. It is very unusual to find an inventor who has had sufficient experience to prepare the specification and claims of an application properly, and the chances are about one hundred to one against his

succeeding in drawing claims which adequately protect his invention.

After the application has been placed in condition for allowance, it is allowed by the examiner, after which it goes to the Issue Division of the Patent Office. Then, upon the payment of the final fee of $20, the patent is printed, the grant is prepared and is signed by the Commissioner of Patents, and the patent is issued under the seal of the Patent Office.

Many inventors suppose that when they have secured their patents their troubles are over, but the fact is that if the invention is of any considerable value or worth, the patentee will be beset by a horde of infringers who will attempt to use the invention and secure the benefit of the inventor's thought and ingenuity.

The patentee can protect his rights only by bringing and prosecuting a suit in the Federal Courts and securing an injunction against infringers.

It seems strange that a person who would not think of trespassing upon the real property of another person, or who would not think of interfering with ordinary chattel property belonging to a stranger, will not hesitate to trespass upon the patented property of another, whenever it appears to him that such trespassing would inure to his advantage, considered from a business and financial standpoint.

Notwithstanding the fact that patented property is constantly being subjected to the attacks of infringers, such property is very valuable, and, as has already been pointed out, constitutes the basis of investment of many millions of dollars in the United States, and it has been asserted in a comparatively recent annual report of one of the Commissioners of Patents "that we mainly owe to our patent system such foothold as we have gained during the past fifty years in foreign lands for our manufactured products."

AN 8-FOOT STEEL CHIMNEY, 230 feet in height, has just been completed and will be erected in Mexico. This will be the highest steel chimney in America.

Mechanical and Engineering Section.

Stated Meeting, held Thursday, December 1, 1904.

Physical Characteristics of Certain Bronzes for Steam Uses.

By Strickland L. Kneass,
Member of the Institute.

It is not necessary for the purpose of the present paper to touch upon the history of the bronze alloys, the use of which reaches far back to the dawn of civilization. A vast amount of research has already been given to the subject, and the early methods employed in their production have been entirely superseded, so that even an accurate description would have but little practical value to the modern metallurgist or manufacturer.

The copper-tin alloys in general use vary from 5 to 24 parts by weight of copper to 1 of tin, with a small percentage of either zinc or lead or of both elements. The true binary has a comparatively small part to play in the arts and trades compared with the total amount of bronze in use, because the cost and difficulty of tooling and machining is much greater, and lead, zinc, nickel, phosphorus or aluminum are almost always introduced, producing a beneficial effect upon the physical characteristics. For example, a trace of zinc is used in a 5 to 1 mixture for certain kinds of spindle-bearings or sleeve nuts, producing a metal hard and brittle, having a whitish-gray fracture, machining with a short chip which flies from the tool with great force; care is required to obtain a good smooth surface, but when obtained the bearing wears well under heavy pressures. A ratio of 7 of copper to 1 of tin, and a little more zinc, makes a good hydraulic bronze, with sufficiently high tensile strength for all ordinary purposes, machining well and running solid in the mold, even with large size sections.

Commencing with pure tin and passing through the various proportions of copper until the latter metal is reached,

the appearance of the fracture changes from white, through gray, ash-gray, bluish-red, reddish-yellow to the tile-red of pure copper. The melting point changes at the same time with each increment of copper, until that of the latter metal is reached. According to Mallet, the maximum density of the alloy is somewhat above that of copper, and occurs when the proportions by weight are about 3 of copper to 1 of tin.

The chemical union of copper and tin in more than one or two proportions is disputed by many authorities, although the statement has been made before this Institute, that 1 to 1, 1 to 2, 1 to 3 and 1 to 4 are probably alloys.* Be this as it may, in the actual behavior of the binary alloy in the foundry, owing to imperfect mixing or to other reasons, there is almost always found a certain amount of liquation and a proportion of eutectic alloy which affect the physical characteristics.

This subsidiary alloy is much more in evidence, and its presence and amount of greater importance in the quaternary alloys or mixtures of copper, tin, lead and zinc, with which we have to deal in this discussion. Here there is always liquation, depending upon the form and size of the section and the rapidity of cooling. For this reason, great care is required to obtain a perfectly homogeneous mixture, approaching as nearly as possible a chemical alloy, free from microscopic pin holes due to shrinkage or to occluded gases, and without the harder spots or lumps of eutectic alloy of the constituent metals. This is where the skill and care of the foundryman, designer and molder, as well as the composition of the metal, play an important part. The rapidity of melting, temperature of pouring and the condition of the mold itself, all affecting the results.

The essential characteristics of a good steam metal are, homogeneity, solidity, tensile strength, rigidity, facility for machining, fluidity in casting, and non-corrosiveness, all being supplied by the various mixtures of bronze in use in

* See this *Journal*, **199**, 26. *Art.* Outerbridge, Microstructure of Bronzes.

varying degrees of excellence. With reference to the composition it may be said in general that homogeneity depends upon the causes already cited; tensile strength and rigidity upon the proportion of copper to tin and their preponderance over the lead and zinc, while the form and character of the chip is determined chiefly by the percentage of lead and fluidity by the zinc. The proper mixture for any desired purpose must, therefore, be a compromise, with a fixed tendency toward homogeneity and density, and it is not an easy matter to obtain the desired results in foundry work without careful attention to detail and consistent experiment.

And experimental work should not be limited to the examination of etched sections, nor should conclusions be drawn from one set of castings. Specific gravity tests and microscopic examinations are also necessary to cover the field satisfactorily, and are of as much importance in the examination of the physical properties of bronze steam metals, as of iron or steel, and such tests should be repeated at periodic intervals to determine the regularity of product of the foundry.

Bronze castings, both finished and unfinished, are subjected in service to two serious deteriotating agencies, namely, the attrition and the solvent action of the contained fluids. These effects are scarcely noticeable on the rough casting, surfaced as received from the mold or after subjection to the sand blast or cleaning bath, but finished surfaces are often seriously affected. The same result that is obtained in the laboratory by etching polished sections, occurs in practice on an exposed valve or seat, except that the final result is not so satisfactory; the more soluble metals or alloys are dissolved by the acidulous or alkaline solution, leaving the more resisting and harder eutectic alloy to protrude above the surfaces, preventing continuous contact between the valve faces. Further, the high velocity of the fluid passing through a throttled valve, cuts out the softer parts and a bad leak and defective seat soon result.

The porosity of the casting deserves serious consideration, even though the openings be not visible to the naked

eye. These defects are seldom observed with a high-power microscope, with the vertical illumination usually employed. The degree of porosity generally depends upon the size of the casting and the part of the section chosen for examination, and is a function of the rapidity with which the molten metal is cooled.

Referring to the effect of attrition in special cases, it may be said that when an injector for feeding boilers is operated at its minimum capacity, the velocity of the jet of water and partly condensed steam may reach 800 feet per second, with a side pressure against the walls of the tube of from 80 to 100 pounds per square inch. If to the passing fluid be added a percentage of sand or dirt often contained in the water supply, the abrasive effect is rapid. A steam line carrying 200 pounds pressure gives a maximum velocity of discharge through a throttled valve of 1,400 feet per second. Hydraulic valves made of bronze are frequently subjected to a pressure of 4,000 pounds per square inch, and the velocity of the water or oil through the constricted orifice between the supply and exhaust may reach 2,400 feet per second during the opening or closing of the valve. The abrasive effect in the cases cited is therefore obvious, and any defect in the surface of the metals exposed to such action is sure to cause rapid deterioration in the operation and efficiency of the device. In injectors made of defective material, the tubes wear out rapidly, not only losing their correct proportions, but, owing to the peculiar action of the jet of steam in apparatus of this kind, grooves and depressions are cut in the inner walls, which cause a ricochetting action from one side of the tube to the other, and which finally prevents the jet from passing into the boiler. The harder protruding spots of the eutectic remain unaffected, while the softer parts directly behind them and exposed to the abrasive action of the fluids, are cut below the normal surface. In the steam-nozzle of an injector, this effect is more marked when a large percentage of water is carried, while dry steam does but little harm to a well-designed nozzle, made of good bronze of even density.

As strength and rigidity are largely questions of the pro-

portions of parts in the design, it is my intention to lay special stress upon homogeneity and density.

Without giving the full details of the investigations, it may be of interest to suggest an outline of the experiments to determine the effect of foundry practice upon the density and homogeneity of certain bronzes. A number of tests were made of various mixtures of copper, tin, lead and zinc having a specific gravity of from 8·5 to 8·9, and an ultimate tensile strength from 25,000 to 30,000 pounds per square inch. The test pieces were turned to $\frac{5}{8}$ inch diameter and 6 inches long, while the specimens for microscopic examination were flat discs about $\frac{1}{8}$ inch thick and $1\frac{1}{2}$ inch diameter and short cylinders about $\frac{3}{4}$ inch x $\frac{5}{8}$ inch. The test pieces were strained to breakage, and the specimen sections etched and examined microscopically for distribution of liquation, or surfaced for determination of porosity, while the densities of both sets were obtained. It was found that great care was necessary in preparing specimens for examination under the microscope for porosity; a sharp tool and a fine feed must be used to avoid the burnishing effect of a facing tool, as the latter closes up the pores to a great extent; it is also necessary to use a high cutting speed to prevent the tearing of the metal.

One of the most obvious causes of variation of the quality of steam bronzes is careless mixing of the fluid metal before pouring, yet it is seldom that this is thoroughly done. The great difference in the specific gravities causes the lead to preponderate at the bottom. An extreme case of this kind was proved by specimens, taken from similar castings, poured from the top and bottom of a bail-pot without special stirring; only a trace of lead was found in the first specimen, and the chips curled like steel turnings; the casting from the bottom of the pot contained three times the required amount of lead, was of a dull color and unfit for use.

A careful determination was afterward made of results that might be expected under best conditions; four small cylindrical test-pieces of dimensions already given were taken from the first and last mold poured:

FIRST MOLD.

Specimen No. 1, specific gravity	8·539
" " 2, " "	8·529
" " 3, " "	8·555
" " 4, " "	8·530
Average specific gravity	8·553

LAST MOLD.

Specimen No. 1, specific gravity	8·309
" " 2, " "	8·368
" " 3, " "	8·320
" " 4, " "	8·339
Average specific gravity	8·340

The individual tests are given to show their consistency and the regularity of the composition of the metal; the difference in specific gravity of the two groups is 2·8 per cent., and the castings made first are slightly denser. Four flat discs from the first mold had an average specific gravity of 8·267 and from the last mold 8·010, a variation of 3 per cent. in the same direction. Two more tests of this kind were made, the differences in the specific gravity of each corresponding closely to the table above, the increase in density in the castings from the first part of the heat being respectively 2·9 and 3·4 per cent. The conclusion to be drawn is that there is no difficulty in obtaining castings of uniform density if the metal is properly mixed. The slight increase in those first poured is probably owing to the lower temperature of pouring, due to exposure during preparation and skimming, and consequent more rapid setting in the mold.

The effect of rapid cooling is well known, and is used successfully with almost every metal or alloy. In the proper production of the steam bronzes it is of great importance and produces a marked effect, increasing the density, reducing the porosity and rendering the etched section much more uniform, causing a great reduction in the amount of liquation and the number of projecting points of the eutectic alloy. Two groups of test pieces were obtained and tested with the following results:

SHORT CYLINDERS.

Average specific gravity of specimens poured hot	8·661
" " " " " " cold	8·915

FLAT DISCS.

Average specific gravity specimens poured hot . . . . . 8·595
" " " " " cold . . . . . 8·598

showing a 3 per cent. gain as before for the short cylinders of small diameter, and practically no change for the larger sections. To determine the effect of maximum practical rapidity of cooling, a small casting was made in an iron mold, and compared with sand contact.

Specific gravity of casting poured in iron mold . . . . . 9·285
" " " " " " sand . . . . . 8·610
Increase due to rapid cooling, 7·2 per cent.

The appearance of the fracture was different; the grain was closer and the tensile strength was higher. Under the microscope the difference was apparent, there being much less liquation, without visible porosity and with great reduction in the number of projecting points of the eutectic.

Unless excessive internal pressures are used, high ultimate tensile strength is seldom needed, as it is customary to increase the section rather than sacrifice other qualities. When the strength is increased by the addition of aluminum or phosphorus, the expense of remelting the enlarged gates and risers becomes an important item, and there is additional risk of porosity in castings of variable section. Rigidity of form, on the other hand, is of great practical value, so that under strain the castings may not lose their original form or alignment. For all ordinary commercial uses of the steam bronzes, an ultimate tensile strength of from 27,000 to 30,000 pounds per square inch is sufficient, and to obtain this value as well as both homogeneity and solidity, careful and conscientious treatment in the foundry is required.

As has been shown, the characteristics of any one mixture of metals producing a steam bronze, vary with the conditions under which the castings are made. Authorities recognize this fact and give a maximum and minimum value of the specific gravity, because no absolute value can be taken. The location of the casting in the mold, the size of the section, the contiguity of large and small masses, as well as the conditions already referred to, affect the den-

sity and the homogeneity. In my investigations, the specific gravities have been determined by our fellow-member, Prof. A. E. Outerbridge, Jr., a statement which is a sufficient guarantee of accuracy. Many were repeated several times, and test pieces cut in halves, to ascertain if there might be any variation shown by smaller sections. The results may, therefore, be accepted as relatively correct and exact as applied to the specimens submitted. The investigations of these steam bronzes also include the position and location of the pattern in the mold and the methods of gating; where a large and small section are contiguous, it is advantageous to place the heavy part of the pattern, having the larger volume in proportion to surface, in a position where it shall be filled by the first poured and cooler metal; it has been found better in certain cases to place the heavier part above and then gate from the lower end of the smaller section. As the larger part is filled with metal at a lower temperature, it cools in about the same time or slightly in advance of the metal in the smaller section, producing a dense casting, free from shrink holes.

In conclusion, it may be said that in many important lines in which the steam or allied bronzes are in use, there are deteriorating agencies at work, acting both mechanically and chemically upon the exposed and vitally important surfaces, which in time destroy the usefulness of the device; the power of the metal to oppose these forces depends chiefly upon the homogeneity and density, and upon these depends the durability of the apparatus.

Finally, these saving qualities can be obtained only by the use of the microscope and the testing machine and retained by careful attention to every detail in the foundry.

DISCUSSION.

MR. G. H. CLAMER:—Mr. Kneass has brought out some very interesting facts relative to alloys which may be used for steam purposes, and their manipulation in the foundry, but he failed to make mention of one very important factor, which will produce a metal sufficiently dense to withstand the high pressures which such an alloy is called upon

to resist. I refer to the admixture to such an alloy of a small quantity of lead. It has long been known by foundrymen that a mixture of a small quantity of lead will produce this effect, and, further, it facilitates the machining of castings which contain it. I know of a very interesting experience bearing on this subject, viz.:

In the time of the old bronze cannons, which were made from an alloy (known as "cannon bronze") of copper and tin, a certain founder had taken a government contract for the manufacture of quite a number of guns of this character. According to the specifications, the government inspectors were required to weigh the charges, see that they were charged in the furnaces and then the foundryman was held responsible for the castings. These guns were subjected to certain pressure, and, after repeated failures, the manufacturers, being familiar with the value of lead in the alloy, decided to have some molds made of the exact shape in which pure tin was marketed. One night they melted the tin which they had on hand, and added a certain small percentage of lead, then poured it into molds, and when the inspector came the next day he weighed the pigs, which he had no reason to suspect were anything else but pure tin. The mixture was then made up in the usual way, and to the utter surprise of the government officials the castings from that day all came up to the full requirements.

There has been another point mentioned by Mr. Kneass, viz., the difficulties which are sometimes encountered, due to the presence of the eutectic.

What is now known by the name of "eutectic" to the old founders was known as "tin spots," and it was with the idea of removing these that the old bell founders tried various expedients, notably the addition of metallic silver, etc.

In our daily production of alloys containing copper and tin, the presence of the eutectic can be observed. In casting ingots of phosphor-bronze, which contain 80 per cent. copper, 10 per cent. tin and 10 per cent. lead, its presence is very often manifested by the appearance of globules on top of the ingots. These, when subjected to analysis, are found

to contain approximately 22 per cent. tin, 2 per cent. lead, 74 per cent. copper and perhaps 2 per cent. to 3 per cent. phosphorus. This quite likely is a complicated quadruple eutectic. It demonstrates that phosphorus in phosphor-bronze is contained almost entirely in the eutectic part of the alloy, and it is due to this that phosphor-bronze is so materially harder than alloys of the same composition which do not contain it.

PROF. A. E. OUTERBRIDGE, JR.:—There is one explanatory statement in Mr. Kneass' excellent paper to which I wish to offer a slight modification. He attributes the greatly increased density and finer texture of test samples of bronze cast in an iron mold, as compared with similar samples of the same bronze metal cast in a sand mold, entirely to the more rapid cooling of the metal when cast in the iron mold. I have made very many experiments in this direction, covering a period of sixteen years or more, and the result is that I attribute the phenomenon mainly to what I call "fluid compression."

You may ask what do I mean by fluid compression in this connection? I mean simply this: Certain alloys of metals expand with enormous force at the moment of cooling. It is due to this fact that we are enabled to obtain sharp castings. Pure copper, pure silver, pure gold, etc., do not give sharp castings, because they do not expand greatly at the moment of cooling.

When such an alloy as that referred to by Mr. Kneass is cast in a sand mold, it first fills the mold, and then when pouring has ceased it suddenly expands and forces the yielding grains of sand outwards in all directions, making a larger cavity than before. A skin of cooled metal forms immediately; then contraction of the mass begins to take place, the thick sections cool more slowly than the thin sections, giving rise to "segregation" and to spongy spots or porous places, while the whole texture of the congealed metal is of coarser grain than it would have been if it had been subjected to mechanical pressure when in a plastic state.

When this alloy is cast in a metal mold the expansion at

the moment of cooling takes place as before, but encounters the rigid walls of the mold, and, therefore, *fluid compression of the molecules of the metal itself* takes place. The internal pressure is frequently sufficient to cause the fluid portion of the metal to burst through the "skin," formed on the upper surface of an open metal mold, where the casting has congealed by exposure to the air, forming pimples of eutectic alloy, and in some cases long filaments curling over in horn-like shapes are extruded.

On cutting a section, through an ingot or casting made in a metal mold, then polishing and etching, it will always be found much denser, more uniform in texture, and much more free from segregation, than the same metal cast in a sand mold, while the specific gravity is also considerably higher. Such metal is not necessarily harder than when cast in sand, though the "chips" are quite different in appearance. It may be likened to the difference in density and fineness of grain observed in a piece of pine wood that has been squeezed in a powerful hydraulic press, as compared with a piece of the same wood not compressed. Metallic alloys which have been subjected to this fluid compression show greatly increased tensile strength. These are facts not generally understood, all having important practical application in the metallurgical arts.

MR. KNEASS:—The chief advantage in the use of lead in steam bronzes is to reduce the length of the chip and the cost of machining, as stated in the paper; the percentage should be small, not exceeding 3 per cent. There is no doubt but that its presence adds somewhat to the solidity, but when a small amount of zinc is also present the function of the lead is to reduce the cost of finishing the castings. The Bureau of Supplies and Accounts of the Navy Department of the United States limits the lead in steam bronzes to 1 per cent., while the Bureau of Steam Engineering omits it entirely.

Referring to the experiments where castings were made in an iron mold, there is no doubt that fluid compression plays some part, but considerable investigation would be required to determine the extent. The theory suggested

by Mr. Outerbridge is interesting, and may account for the unusually high density of this group of test pieces.

RECOVERY OF TIN FROM SCRAP.

The treatment of new tin scrap, known as "detinning," has become of considerable importance in the United States, and at least ten companies were actively engaged in this special branch of the industry during the year 1903. The average yield from tin scrap is approximately 2 per cent. of metallic tin. In addition, a large number of small concerns in the principal cities recover the tin from old tin cans and similar material by a smelting treatment in a furnace, the tin being obtained in the form of solder, which is either used as a basis for making new solder or is treated chemically to yield metallic tin or tin salts. The residue of scrap iron is generally utilized in the manufacture of sash weights and other castings of inferior quality of iron.

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, December 21, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 21, 1904.

PRESIDENT JOHN BIRKINBINE in the chair.

Present, 92 members and visitors.

Additions to membership since last report, 14.

The major part of the meeting was devoted to the St. Louis Exposition.

The subject was introduced by Prof. Lewis M. Haupt, who gave a general historical sketch of the origin and development of exhibitions in general, and followed with a general description of the St. Louis Exposition, the latest and in many respects the greatest of them. His remarks were illustrated by a series of views of the grounds and buildings.

Mr. Samuel M. Vauclain, Superintendent of the Baldwin Locomotive Works, followed with a detailed account of the more important features of the exhibits in the Transportation Building. His remarks were devoted largely to the exhibits of locomotives and rolling stock, and were profusely illustrated with lantern photographs.

Prof. Carl Hering followed with some informal notes and comments on the electrical features of the exhibition.

Prof. L. F. Rondinella then read a paper on the making of long photoprints, with special reference to an improved machine of this kind, which he had devised, which he exhibited and described, and subsequently showed in operation. Several specimen prints, one of them 19 feet long (made in twenty minutes), were exhibited as the product of the machine, which was stated by the speaker to be capable of making a print 70 feet long.

The invention was referred to the Committee on Science and the Arts for investigation and report.

Mr. W. N. Jennings then exhibited and commented on some unusually interesting lightning photographs, showing the repeated striking of the tower of the City Hall.

Mr. Waldemar Lee, duly seconded, offered the following preamble and resolution, which, after some discussion, were adopted, viz.:

"WHEREAS, Alcohol is a necessary material in the manufacture of many important articles of commerce; and

"WHEREAS, An important group of American industries has thus far been dwarfed by the lack of free alcohol in the arts and manufactures, and for the ostensible reason that it was difficult for our revenue authorities to prevent its use otherwise than for these purposes; and

"WHEREAS, Competing nations, notably, Germany, France and England, find no difficulty in prescribing and enforcing regulations to prevent such use.

"*Resolved*, That in the opinion of the Franklin Institute it is the duty of Congress and our revenue authorities to afford our manufacturers equal facilities in this respect with those of competing nations, and at the same time benefit our agricultural interests by affording an increased use for our greatest cereal crop. We therefore favor the passage of the bill introduced by Representative Boutelle, H. R. 9,302."

The following nominations for officers, managers and committeemen were made, to be voted for at the annual election to be held on Wednesday, January 18, 1905, between the hours of 4 to 8 P.M., viz.:

For President	(to serve one year)	JOHN BIRKINBINE.
" *Vice-President*	(" three years)	WASHINGTON JONES.
" *Secretary*	(" one year)	WM. H. WAHL.
" *Treasurer*	(" ")	SAMUEL SARTAIN.
" *Auditor*	(" three years)	WM. H. GREENE.

For *Managers* (to serve three years).

EDWIN S. BALCH,	LOUIS E. LEVY,
WALTON CLARK,	CHAS. LONGSTRETH,
THOS. P. CONARD,	ISAAC NORRIS,
CHAS. HENRY HOWSON,	COLEMAN SELLERS.

For *the Committee on Science and the Arts* (to serve three years).

A. W. ALLEN,	W. C. L. EGLIN,	GEO. P. SCHOLL,
HUGO BILGRAM,	E. GOLDSMITH,	E. ALEX. SCOTT,
AMOS P. BROWN,	LEWIS M. HAUPT,	COLEMAN SELLERS,
FRANK P. BROWN,	LUCIEN E. PICOLET,	HARRISON SOUDER,
W. W. CANBY,	C. J. REED,	H. W. SPANGLER,
KERN DODGE,	JAS. S. ROGERS,	A. H. STEWART,
D. EPPELSHEIMER, JR.,		MARTIN I. WILBERT.

Adjourned.

WM. H. WAHL,
Secretary.

Committee on Science and the Arts.

Abstract of proceedings of the stated meeting held Wednesday, December 7, 1904.

PROF. LEWIS M. HAUPT in the chair.

The following reports were adopted:

(No. 2327.) *The Glazier Fire Nozzle.* Bradley & Munson, New York.

ABSTRACT: This apparatus is the invention of John T. and Peter F. Glazier, of Indianapolis, Ind., and consists of a hose pipe and connections designed for the purpose of overcoming the difficulty of handling fire streams from hose lines under high-pressure service, and also for the purpose of directing a stream at a specific point continuously without demanding attention from firemen.

The apparatus is a brass play-pipe connected by a swivel joint to a curved waterway attached to a hose connection by a ball-bearing joint so that the play-pipe can be moved in two directions in planes at right angles to each other. In one style (having a single waterway) the stream from the hose after passing through the curve is delivered into a chamber with elliptical cross-section and thence through the play-pipe. In another style (having two curved waterways diverging directly above the ball-bearing joint) the water stream is again united in a well-shaped chamber and passes thence through the play-pipe. Either style can be directly coupled to one hose line, or can be attached to a Siamese hose connection, allowing two or more hose streams to be concentrated through the apparatus.

The report then proceeds to describe a series of tests with the apparatus, which exhibited an average loss of 10 pounds pressure above or below the curved arms, in high-pressure service.

The apparatus is adaptable to various fire department devices, such as monitor wagons, water-towers, and, above all, for use in connection with hose streams in a stationary position without attention of a fireman.

The report awards a Certificate of Merit to the inventors. (*Sub-Committee*, Chas. A. Hexamer, chairman; Wm. McDevitt.)

(No. 2341.) *Expanding and Flanging Machinery and Tools.* Luther D. Lovekin, Philadelphia.

ABSTRACT: These inventions are based on the well-known "Boiler-Tube Expander" introduced by Dudgeon, of New York, but embody many important improvements designed to increase the efficiency and durability of the tools and to adapt them to a much wider range of work. The inventions are covered by the following letters-patent of the United States: No. 723,289, March 29, 1903; Nos. 734,271, 2, 3, and 4, July 21, 1903; and Nos. 682,725, 6, September 17, 1901, granted to applicant. A full description of the Lovekin tools and machinery with illustrations will be found in the *Journal of the Franklin Institute*, June–July, 1904, to which reference may be made.

The report concludes as follows: "This system of expanding tubes undoubtedly possesses great merit, and in view of the great advantages conferred

upon the shipbuilding and other important engineering industries thereby, and the great ingenuity displayed by the inventor in working out the system in its various forms and details, the Franklin Institute awards the Elliott-Cresson Medal to Louis D. Lovekin." (*Sub-Committee*, Thos. P. Conard, chairman; J. M. Emanuel, John Haug.)

(No. 2350.) *Instantaneous Automatic Water Heater.* Edward Ruud, Pittsburg, Pa.

ABSTRACT: This invention is one of many devices intended for domestic service, in which the opening of a hot-water faucet anywhere on the house line will speedily be followed by a continuous supply of hot water.

The operative mechanism consists of a coil boiler (of copper) supplied from the house distributing system and connected by means of a by-pass with a valve controlling the gas supply of the house service. This gas valve is actuated by the opening or closing of the hot-water faucets of the house water supply. This valve is so adjusted as to respond sensitively to the water pressure when this is thrown on or off by the opening or closing of a hot-water faucet in the house. A small pilot light, which is left burning constantly, serves the purpose of igniting the series of burners of the heater coil, through which the water supply must find its way to the point of consumption.

The report finds that this Ruud contrivance accomplishes its intended purpose satisfactorily and possesses advantages over others of its class in respect of greater freedom from clogging up of burners by dust, etc., and convenience of access for inspection and repairs. The award of the Edward Longstreth Medal is made to the inventor. (*Sub-Committee*, Charles E. Ronaldson, chairman; F. P. Brown, W. O. Griggs, I. M. Emanuel.)

The following reports passed first reading:

(No. 2331.) *The Burglar Immunity Company's System of Electric Protection.*

(No. 2345.) *The Flexible Compound Company's Products.*

(No. 2348.) *Mucklé's Elevator Safety System.* W.

Sections.

[*Abstracts of Proceedings of Stated Meetings.*]

MECHANICAL AND ENGINEERING SECTION.—*Stated Meeting*, held Thursday, December 1st, 8 P.M. Mr. G. H. Clamer in the chair. Present, 86 members and visitors.

The first paper of the evening was read by Mr. Samuel M. Vauclain, Superintendent of the Baldwin Locomotive Works, Philadelphia, on "Rolled Steel Car Wheels." The speaker made comparison between the old style chilled cast-iron wheel and the modern rolled steel wheel, and proceeded to describe the method of manufacture practised by the Baldwin Works. A free discussion followed, participated in by Messrs. J. S. Whitney, A. E. Outerbridge, G. H. Clamer, and the speaker. Mr. Strickland Kneass, of Wm. Sellers & Co., Philadelphia, followed with a brief paper on the "Physical Characteristics of Bronzes Used for Steam Purposes," which was discussed by

Messrs. Clamer and Outerbridge. The papers with discussion were referred for publication, and the speakers were given a vote of thanks.

Adjourned.

I. EPPELSHEIMER, JR.,
Secretary.

ELECTRICAL SECTION.—*Stated Meeting*, held Thursday, December 8th, 8 P.M. Mr. Thomas Spencer in the chair. Present, 68 members and visitors.

Prof. W. S. Franklin, of Lehigh University, read a paper on "Long-distance Transmission Lines," which he illustrated with the aid of a number of models and photographs.

Mr. H. Clyde Snook, of the Roentgen Ray Manufacturing Company, Philadelphia, followed with a description of an improved "Ampere-Meter for High-Potential Currents," which he exhibited and demonstrated in operation. Both papers were freely discussed and referred for publication.

Adjourned.

RICHARD L. BINDER,
Secretary.

CHEMICAL SECTION.—*Stated Meeting*, held Thursday, December 15th, 8 P.M., Dr. Robert H. Bradbury in the chair.

Prof. E. B. Voorhees, Director of the New Jersey Agricultural Experiment Station, New Brunswick, N. J., presented a communication on the "Sources of Supply and Methods of Manufacture of Phosphates and Potash Salts," illustrating his remarks by the exhibition of a large number of lantern photographs.

The speaker's remarks embraced an account of the occurrences and characteristics of the several important phosphate deposits in the United States, including especially those of South Carolina, Florida, and the more recently discovered beds in Tennessee. This was followed by an interesting account of the famous potash salt deposits of Stassfort. Discussed by Drs. R. H. Bradbury and W. J. Williams, and Mr. Waldemar Lee. The meeting passed a vote of thanks to the speaker.

Adjourned.

W. E. RIDENOUR,
Secretary.

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, held Thursday, December 22d, 8 P.M. Mr. C. H. Clamer in the chair. Present, 32 members and visitors.

The chairman presented Mr. Edward A. Uehling, of New York, who read a highly interesting paper on the "Fundamental Principles Involved in Blast-Furnace Practice." The paper was discussed quite fully by Prof. A. E. Outerbridge, Dr. Geo. P. Scholl, Dr. Edward Goldsmith, Mr. Walter Wood, Mr. Clamer and the author. (Paper and discussion will appear in due course in the *Journal*.)

The chairman expressed the thanks of the meeting to the author of the paper and adjourned the session.

WM. H. WAHL,
Secretary pro tem.